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**LIGHT INTO ARCHITECTURE:
EVOCATIVE ASPECTS OF NATURAL LIGHT AS RELATED TO
LITURGY IN BYZANTINE CHURCHES**

by

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A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
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Στους Γονείς μου
και
στην Συζυγο μου

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PREFACE

What I find extraordinary about certain settings is their power to transport, to become vehicles for the human mind, impelling it to reach worlds that may exist only in the realms of imagination, of vision, or of faith. I was amazed to discover, through a long and arduous process, that architecture is in fact capable of such feats through the employment of purely architectonic means. Accordingly, this study seeks to clarify some of the means used to create the unique atmosphere peculiar to Byzantine churches through the remarkable manipulation of light. This study might never have taken place were it not for certain fortuitous circumstances that made it possible for me to experience certain events whose meaning in respect to architecture I began to appreciate some years later.

Apart from seeking to fill a manifest void in architectural and art scholarship there have been several reasons that motivated me to investigate the methods and techniques of, as well as the philosophy and the religious imagery underlying, the lighting design in Byzantine religious architecture. The first springs from the contention that architecture can be more than a play of forms designed to attract the eye. The innate nature of architectural space, at once three-dimensional and offering enclosure, tends to form a fundamental frame of reference for the ways in which human beings conceive the world. One of the reasons for this is that architecture incorporates the dimension of time. In response to the cyclical character of time -- as it is perceived on earth by the alternation of day and night and the seasons -- the architectural artifice can be transformed into an object with an expressive life of its own that may appear more congenial not to the eyes alone, but to human existence as a whole. Perhaps the most powerful agent for communicating this temporal aspect of

architecture is natural light, and Byzantine churches appear to have exploited its potential imaginatively.

The second reason for undertaking this dissertation is to examine the capacity of natural light not only to evoke this sense of the passage of time, but also, by means of its constant motion and interplay, to imbue space with a variety of moods and to energize architectural forms with expressive qualities. By its constantly changing aspect and dynamic interaction with the building forms, natural light creates spatial impressions that can instantly affect, and sometimes play a principal role in shaping, human moods. The manner in which light is let into a given space lends a particular character to that space which may be regarded as being conducive to heightening and enhancing certain kinds of psychic states; if carefully modulated, such manipulated light may even prove capable of predisposing the viewer toward a particular conception of the world, as in this case the one fostered by the Church. The importance of light in architecture is seldom recognized in this capacity.

The third reason for embarking upon this study stems from the author's having experienced certain emotionally powerful events in the Byzantine churches of the Mount Athos monasteries in Northern Greece, involving effects produced by both natural and artificial light. These effects suggested that in times past, when people were more deeply engaged in religious visions, steps aimed at intensifying religious experience were taken consciously and involved careful planning on the part of the architect. Subsequently, repeated opportunities to observe the Mount Athos churches led the author to formulate the theory advanced in this dissertation.

It is hoped that this study will not be only of archaeological appeal, but will revive interest in the ways in which light, by being subjected to definite design principles, is capable of amplifying particular experiences. This elucidation, it is further hoped, will open up a new avenue of thinking about design and serve as a source of inspiration and insight for our contemporary architecture.

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INTRODUCTION

Background

Byzantine architecture has often been characterized as possessing an overall theatrical tendency in both secular and religious buildings. According to Otto Von Simson, “Byzantine man was a Homo Ludens. To him the world was a theater, created and directed by the Divine Poet.”¹ This theatrical tendency is not only encountered in imperial structures of great size and complexity, but also seems to permeate even the humblest architectural settings.² The predilection for strong experiential effects seem to have constituted an important component not only of politics³ but of church liturgy and ritual as well. In the latter context, the evocative potentials of light appear to have been explored extensively for the purpose of amplifying the dramatic appeal of church interiors. The intensification of religious experience by visual and other means aimed at rendering comprehensible the nature of the divine, which in itself was thought to be inaccessible to the senses.

Although the various visual effects in Byzantine churches have frequently been discussed,⁴ the mysterious and evocative qualities of natural light and its capacity to heighten pious sentiments in these churches have only been noted in passing by scholars. Such intangible qualities of space usually tend either to be regarded as poetic interpretations or to be dismissed altogether as subjective responses of the individual viewer. They are seldom considered to be programmatically designed aspects of the building. As a result, the impact and contributions of the manipulation of light in creating the dynamic atmosphere of Byzantine church interiors has yet to receive adequate attention.

Conversely, the forms of Byzantine architecture have mostly been explained in terms of Eastern or Roman precedents, limitations of building technology, constructional necessities, or strictly functional liturgical requirements. This suggests a certain prejudice on the part of our contemporary culture, which tends to ascribe primitivist tendencies to

technologically inferior historical periods and which often conceives of sophistication as progressing in a linear fashion from past to present.

The Subject

The main goal of this dissertation is to examine the mysterious atmosphere of Byzantine church interiors and determine the degree to which this atmosphere owes its character to purposeful manipulations of natural light. This dissertation claims that this atmosphere was, in fact, intentionally conceived and implemented by Byzantine designers and that the feelings experienced in such buildings are not simply the result of subjective perceptions of emotionally charged individuals who were intensely driven by their faith. This characteristic atmosphere is felt in many Byzantine churches regardless of the predilection of the observer while it is lacking in modern church interiors of the same denomination, which are plain and uninspiring in comparison despite their employment of a similar style and sumptuous decoration. Hence, it would appear logical to investigate for evidence of architectural intervention that could account for the sources of this particular character.

An analysis of this kind of atmosphere whose singular aspect obtains from variations of constantly moving light might easily be dismissed as imaginary unless certain consistent phenomena, providing evidence of intentional conception and implementation, could be isolated and plainly demonstrated. This dissertation argues that phenomena of this sort do occur in a consistent manner, thereby indicating overt, systematic intention. Indeed, the fundamental hypothesis of the dissertation is that Byzantine architecture made conscious, systematic use of natural light for evocative purposes. It is argued that certain concrete lighting design principles were developed and followed by the architects and builders of Byzantine churches. Even though the lighting effects in Byzantine churches are quite varied, some of them seem to have persisted. This persistence may be explained by the fact that the lighting effects in question constituted an indispensable component

for performing the liturgy and enhancing religious experience. Specifically the dissertation seeks to elucidate certain principles which have been gleaned from historical and scriptural as well as physical evidence. Thus it begins by examining the manner in which religious, canonical, and philosophical principles found expression in certain architectural gestures whose effects were further heightened by appropriate manipulations of light. It analyzes systematically the ample references concerning the significance of light and the focused attention on its evocative and didactic qualities discerned in the religious literature from the early Christian centuries. It discusses the attention to the qualities of light detected in philosophical writings preceding or concurrent with the time of development of the liturgy.

Thus informed and based on the observation of the succession of lighting effects the dissertation seeks to synthesize the underlying overall lighting scheme, and identify the phenomena that seem to emphasize visually the message intended to be conveyed by the service (Figs. I.1, I.2).

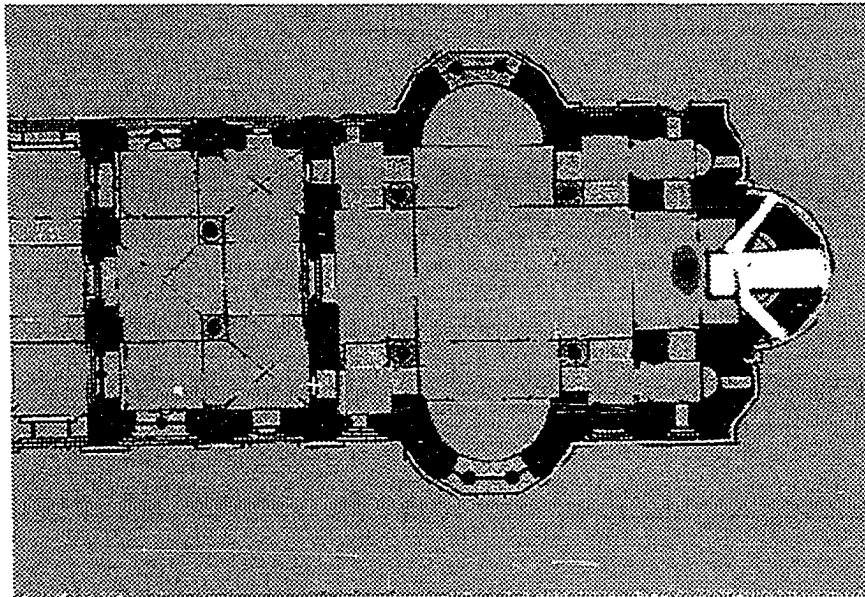


Fig. I.1 Church Plan showing light shafts coming onto the altar on the third hour from different windows in the different seasons.

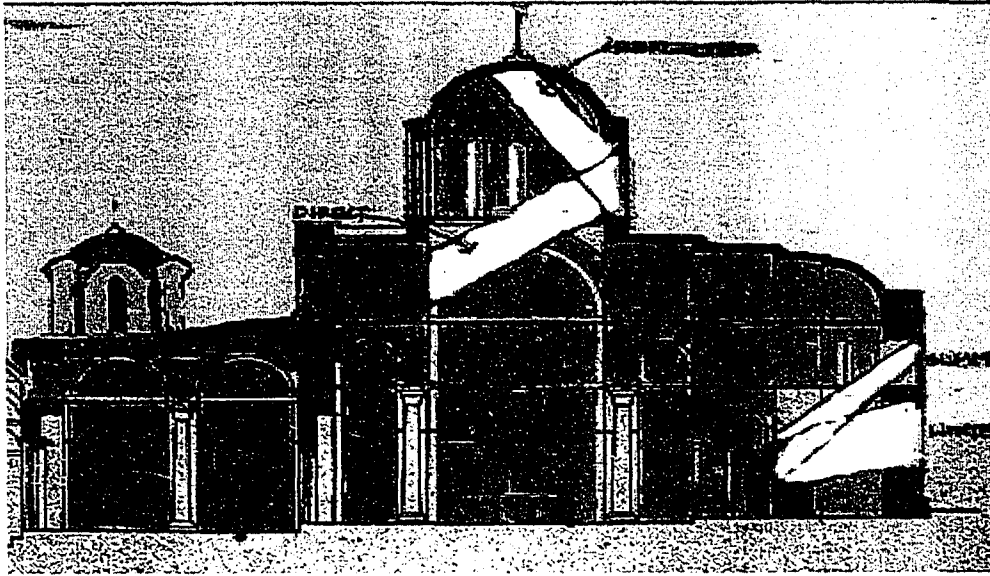


Fig. 1.2 Church Section showing reflected light onto the apex of the dome and direct light onto the frescoes in the nave and onto the altar.

The first phenomenon identified is the reception of light shafts onto the altar in midmorning. This phenomenon occurs during certain occasions of religious importance during the year and affects the orientation of the church axis. Depending on the frequency of use and the dedication of each church the axis orientation varies in order to admit light shafts on the prescribed time and dates. Thus, a large cathedral or a church of frequent use would tend to be oriented toward the midmorning of the equinox and employ large or even continuous openings in the apse so that it may receive light shafts during many important feasts throughout the year. On the other hand, smaller churches attended once or twice a year and dedicated to one or two Saints or feasts are oriented so as to receive light shafts onto the altar in the midmorning of these occasions alone.

The second phenomenon consists of the radiant apex of the church dome where usually the image of Christ Pantocrator is placed. While the first phenomenon is of a transient, fleeting, and sporadic character this one aims at a constant, unchanging, ever-

lasting image. Reflected light is here implemented and the number of dome windows, the configuration of the window sills and dome curvature are the main determinants of the degree of success of the impression conveyed.

The third phenomenon identified is that of light shafts entering through the dome windows and scanning the church interior illuminating important images placed on the various surfaces and which are hierarchically distributed according to their religious significance and liturgical role.

While all three phenomena are discussed the first two are fully analyzed from religious, canonical, and architectural points of view. This analysis aims at demonstrating that these phenomena had been so designed as to evoke feelings of piety or awe in members of the congregation and to serve as mental vehicles for the faithful to be transported and become immersed in the profound and complex liturgical meanings. Even though no textual sources have been found that explicitly relate religious contemplations in regard to light with Byzantine architecture, there is adequate evidence from both the architectural and philosophical-religious realms that indicates an energetic and focused interest on this subject. As we shall see, the conscious employment of the senses as an aid to mental comprehension and to transference of the mind from worldly to divine thoughts had become an issue of great interest among the religious fathers of the Eastern Church.

The purpose of the present study is not to exaggerate the role and significance of lighting in Byzantine church design but to place the question in sharper historical and empirical focus.

Approach, Method, and Scope

The approach deemed appropriate for investigating this kind of problem is that of simple and direct observation of the atmosphere discerned in selected Byzantine churches and a comparison of their respective geometries orientation, sizes and number of openings, together with their relationship to other forms of the interior, observation of the

relationships of particular phenomena and the respective geometries of building forms attempting to derive conclusion regarding their intended use.

The dissertation is organized in two parts that encompass thematically related chapters of the study. It begins with accounts of observations made in certain Athonite churches in relation to the modulation of light and the arrangement of significant objects, events, and iconographic representations within the church. These initial observations are incorporated in the introduction.

The first part of the study deals with the context within which this approach to design has taken place. It provides historical documentation of the philosophical, religious and artistic contexts and analyzes the liturgical-canonical literature and the detailed interpretations provided by prominent ecclesiastical personalities inasmuch as these pertain to the significance of light. There follows an analysis of the Byzantine calendar and method of time measurement in order to ensure that the light effects under study are understood within the temporal framework in which they were actually implemented and because of their crucial importance in understanding the consisted manipulation of light effects over time. The dissertation continues with a brief presentation of the importance of heavenly bodies for, and the use of natural light in, various religious cults in order to demonstrate that what is to be argued throughout this dissertation may be understood not as a unique phenomenon, but rather as a continuous evolution of ancient traditions inherited and appropriately transformed by Byzantine culture. There follows an examination of certain aspects of Byzantine architectural education and practice in order to provide historical evidence regarding the capacity and readiness of architects to cope with the manipulation of sunlight in very specific terms.

In the second part the basic lighting scheme is analyzed and supported by empirical documentation of individual light effects that have been observed in some important church examples. Over one hundred and thirty churches have been personally examined in various parts of what once was the Byzantine empire including Istanbul, Thessaloniki,

Athens, Mistra, Meteora, Mount Athos, and Rhodes. Additional sites in Asia Minor and Jordan have been studied through scholarly publications. These monuments have revealed consisted variations of their orientation from the accepted norm which appear to be related to the admission of light within the church. A number of these churches was studied more systematically through the collection of historical evidence regarding their construction date and original dedication, and through compass readings of their orientation and calculation of sun angles for significant dates for each one of these. Finally, only twenty-two churches with complete data appear in Appendix 3. These are located in Mount Athos, Thessaloniki, and Istanbul.⁵ The sample of churches selected are not confined to a particular period. They span the entire spectrum from the fifth to the eighteenth century from Early to Post-Byzantine times. Some of them are frequently used cathedrals while others are only used once or twice a year. Some of them belong to monastic establishments while others are intended for use by lay people. Since this is the first study of its kind it attempts to glean the potential existence of some general rules and guidelines rather than establish conclusively the particular tendencies in any one period and culture. An important consideration, however, is the fact that the most important historical and empirical facts have been securely established. Of vital importance for the selection of those churches that were rarely used during the course of the year was the availability and/or establishment of the original celebration dates marking the dedication of the respective churches. The dates of their construction range from early to middle to post Byzantine in order to facilitate investigation of the extent to which a continuity of tradition may be in effect. Many of the churches in the sample are Imperial foundations while for others the source of funding is uncertain. Thus the degree to which locally funded churches followed a similar pattern cannot be established on the basis of the present research.

The method of illuminating the dome has also been observed in a large number of churches. In a few cases more detailed observations were made during the liturgy and

detailed measurements of openings were taken and in several other cases the study of openings as reproduced in scholarly publications have served as the main sample for the substantiation of this light effect. A sophisticated method of resolving this very problem was advanced by Anthemius in a treatise reproduced in Appendix 4. It is cited and discussed in support of the main argument regarding this effect and a direct connection of this problem is made to the original dome of Hagia Sophia.

The Mount Athos churches have served as the point of departure for the observations which led to the formulation of the main argument of this dissertation. The reason for this choice has stemmed from the ability to sense the impact of the interiors on the worshipper as a result of experiencing and perceiving the spaces in question in circumstances that are identical to or approximating as closely as possible the conditions that would originally have prevailed in the given spaces. Only by apprehending the original physical context and setting for the liturgical acts, building forms, and lighting conditions as a whole is it possible to reach an understanding of the role that natural lighting was conceived to play. The lighting schemes in question and their relationship to the liturgy cannot be fully comprehended unless one can experience the conditions reasonably approximating its original use. Modern changes in the liturgical sequence and the time of day in which significant liturgical events are celebrated can make the lighting conditions perceived today appear to be random phenomena that bear no relationship to the liturgical acts and rituals in question.⁶

This concern, which is central to this study, made the monasteries of Mount Athos the most likely and desirable candidates for investigation. Mount Athos, officially established as a Christian monastic center in the 10th century A.D., today constitutes one of the few extant sites that continues uninterrupted the active practice of Byzantine traditions, thereby simulating living vestiges of the bygone Byzantine world. Though the churches of Mount Athos may have undergone considerable alterations and liberal architectural treatment during the thousand years of their continuous inhabitation, the manner

of their present use approximates most closely the original functions and practices of a tenth century Byzantine monastery. The selection of the Mount Athos churches for observation was, therefore, not made on stylistic grounds. Rather, it was governed by the need to examine buildings yielding the closest possible approximation of the original conditions of liturgical use.

In the end, however, these churches did not become the focus for the empirical demonstration of the two main light effects underlying the hypothesis advanced by this study, for three reasons. The first stems from the fact that, for most of them, reliable historical documentation, especially regarding original dedications and foundation circumstances, is lacking; the second, because the mountainous terrain seriously affects the way in which the timing of the effects would be calculated - a problem which could only be solved with the use of sophisticated surveying equipment; third, because the circumstances and extent of later remodelings of the churches that may have altered original intentions is not exactly known. Conversely, the material discovered about Hagia Sophia and in the extant writings of its chief architect have proven unexpectedly rich in relation to the subject of this investigation and called for focused attention and detailed exploration of its probable implications.

It has been observed that the lighting conditions and atmosphere in Byzantine churches vary considerably and appear to assume a distinct character reflective of the historical period in which they were built ⁷ and the specific subculture which they embodied and expressed. This circumstance suggests that the attendant lighting conditions did not simply occur as a byproduct of formal considerations, but must have been carefully and rationally considered during each period, in order to obtain, the noted pattern of consistency within each period.

However, the purpose of this study is not to determine the individual strategies followed in each different period and locale for achieving certain lighting effects. Rather, it focuses on revealing certain key effects and their common canonical basis and in so



Fig. I.3 Philotheou, Mount Athos. NW view of katholikon

doing to plainly demonstrate the concrete manner in which this design aspect was considered in Byzantine times.

Experiencing the Manipulation of Light in Mount Athos Churches

This study was initiated several years after having a certain experience during one of my first visits on Mount Athos in 1981. I had this experience in the church of the monastery of Philotheou (Figure I.3) during the Easter vigil of that year. Not being religiously inclined I was surprised to have been deeply moved by an event that took place before my eyes owing its effect to a simple, yet extremely powerful perceptual illusion, as I understood later.

At the culmination of the customary 14-hour Easter vigil, which is the point of the commemoration of the resurrection of Christ, the two concentric chandeliers,⁸ which are both suspended from the central dome, were set into a swinging and rotating motion by the monks (Figure I.4). As I recall, no other candles or tapers were lit apart from those of the two chandeliers (Figure I.5). Suddenly, the monks fell on their knees or prostrated themselves facing the Holy Gate of the iconostasis and the center of the nave forming something between an elliptical and haphazard pattern on the floor (Figure I.6). At the

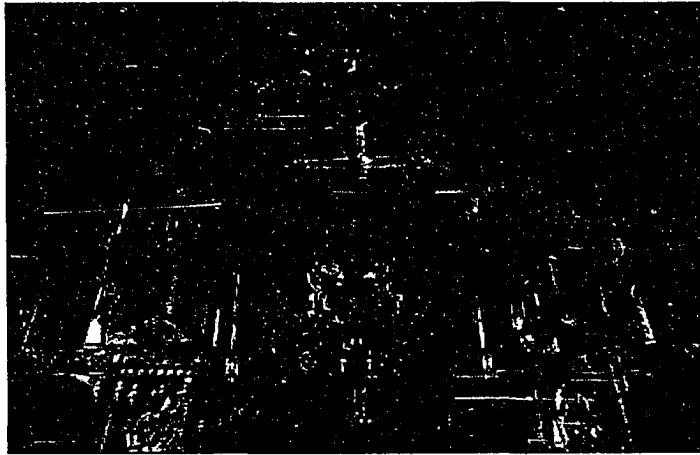


Fig. I.4 Philotheou, Mount Athos. Chandeliers

same time their intense lamentation filled the air overshadowing the psalms.

Not being conscious of what exactly was at work from a perceptual point of view, I had a strong sensation of instability of the material world around me. The building appeared to shake as if by earthquake. By the employment of simple visual and auditory means my senses had been forced to apprehend the happening as an intense and alarming natural phenomenon - that of an earthquake. The chandelier, being the only light source, was involuntarily followed by the observer's eyes and tended to appear as stationary



Fig. I.5 Pantocratoros, Mount Athos. Lit chandeliers, rotating on the day of the coronation of the new abbot

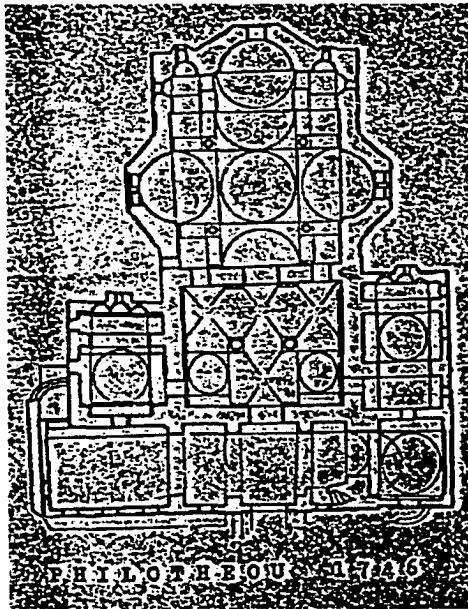


Fig. I.6 Philotheou, Mount Athos. Plan

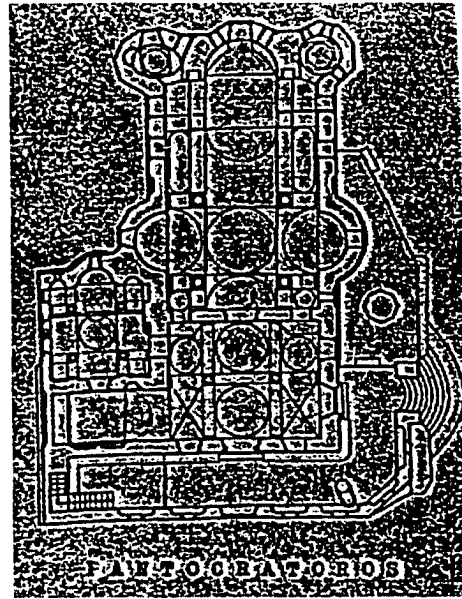


Fig. I.7 Pantokratoros, Mount Athos. Plan

while the building interior appeared to be in motion. This effect, in conjunction with the noise made by the heavy chandelier chains, imparted convincingly the sense of an earthquake. This event left a deep and lasting impression on me.

In June 1993 I became acquainted with the young abbot Efraim of the monastery of Philotheou who answered many of my questions regarding the effects of light in current practices. He became interested in my research, probably regarding it as a vehicle to inspire religious reverence in me. So, he invited me to attend the transformation of the monastery of Pantokrator from the “idiorrhythmic” to the “cenobiotic” system. This event, of seminal importance to the religious life of Mount Athos, consisted of a change in the administrative organization of the monastery with significant consequences on spiritual discipline. This was also the day for the enthronement of a new abbot.

Several thousand people had come to celebrate the event. Unable to attend the mass inside the church because it was full, I experienced it on the outside, from the monastery courtyard (in which the church is located) looking directly into the apse through a northern side-window (Figure I.7). This vantage point provided me with the

opportunity to observe the liturgy as it was taking place within the apse, a view that, in the present day, only few people can have from the nave. There were several priests and abbots sitting on a bench attached to the wall of the main apse, participating in the service performed by the bishop. It was early morning. At the time that the bishop offered bread and wine in dedication to God (a process that lasted about twenty minutes and during which he prayed silently with eyes closed holding the offerings high above his head with both hands) a clearly discernible shaft of light coming from one of the three windows of the apse appeared to envelop both the bishop and the offerings. It was a moving sight. I felt that this could not have been accidental but, unfortunately, the monks prevented me from photographing it. (Figure I.8).

After this event, I began to observe the movement of sunlight and the light shafts in other churches on Mount Athos, seeking to understand whether a coherent lighting design system was actually at work.

During this same visit on Mount Athos I noticed, at the monastery of Osiou Gregoriou, a window on the western wall of the nave which was of unusual circular shape (Figure I.9). Inquiring about its unusual shape and position, I was told that a strong

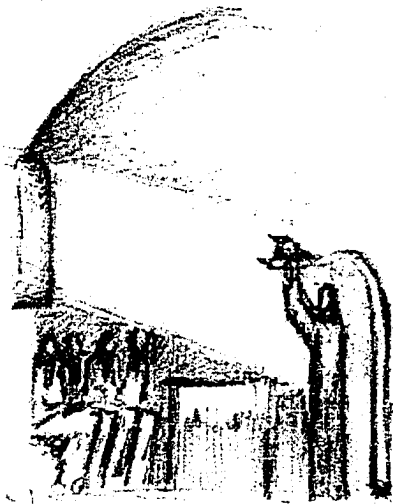


Fig. I.8 Pantokratoros, Mount Athos. Liturgy, author's sketch.

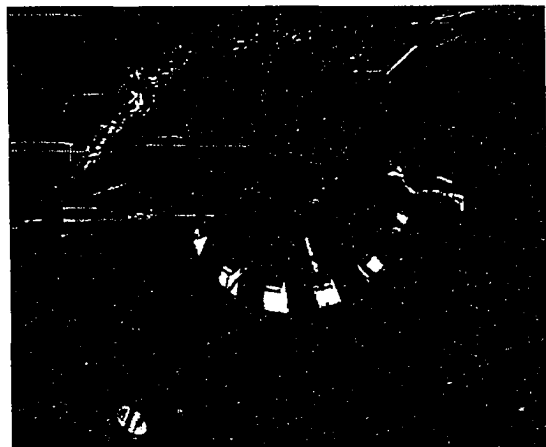


Fig. I.9 Gregoriou, Mount Athos. Circular window on the Western wall of the nave

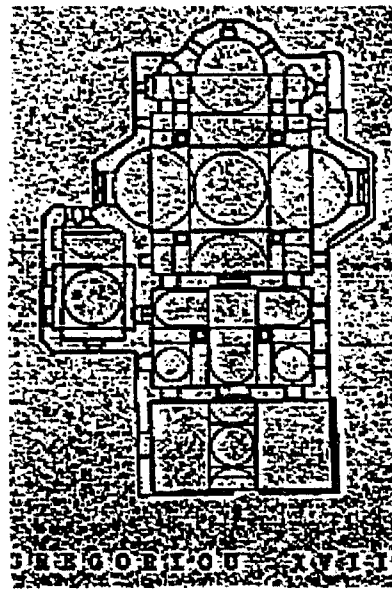


Fig. I.10 Gregoriou, Mount Athos. Plan

shaft of light sometimes comes through this and through the gate of the iconostasis toward the altar during the Vespers.

In another case, again at the monastery of Osiou Gregoriou, I found myself in the Letè, a chamber preceding the nave of the church (Figure I.10), during late afternoon. I noticed a spot of sunlight highlighting only the northeast pendentive which supported a windowless ceiling consisting of a combination of shallow barrel vaults and domes. This pendentive was the only one lighted and the spot disappeared after about a quarter of an hour. This light entered through a window of the northern of the two domes of the Lete. It ended up at this spot after being reflected off the white marble floor. This reflection appeared as if it had been precisely calculated because all other surfaces apart from the pendentive were very dark. This event I was allowed to photograph (Figures I.11, I.12, I.13). In the same church I was also allowed to photograph another event just before the service of the Vespers. Light entering the nave through the dome windows created something akin to pillars of light on either side of the Holy Gate while a spot of light moved slowly through the doors and onto the altar (Figures I.14, I.15, I.16, I.17). During the

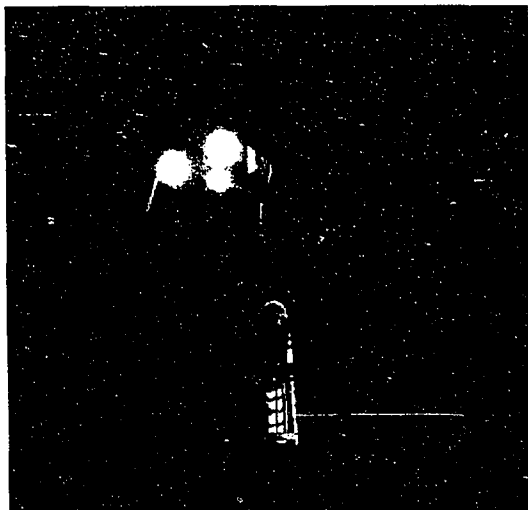


Fig. I.11 Gregoriou, Mount Athos. Shaft of light entering through northern dome of the Narthex.

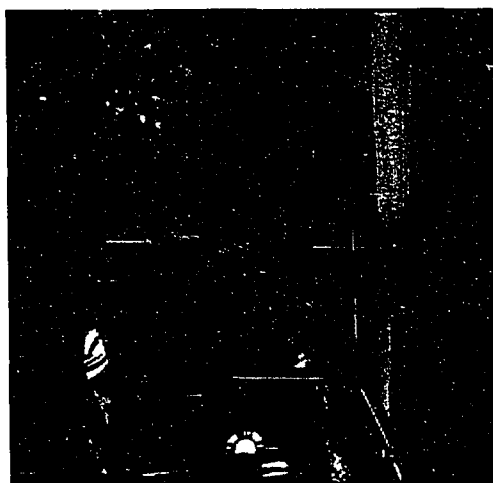


Fig. I.12 Gregoriou, Mount Athos. Highlighted NE pendentive.

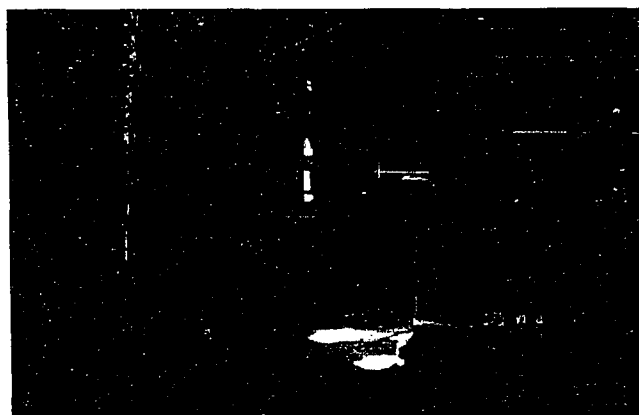


Fig. I.13 Gregoriou, Mount Athos. Reflection of light shaft off the marble floor.



Fig. I.14 Gregoriou, Mount Athos. Pillars of light on either side of holy gate.



Fig. I.15 Gregoriou, Mount Athos. View of nave from narthex.

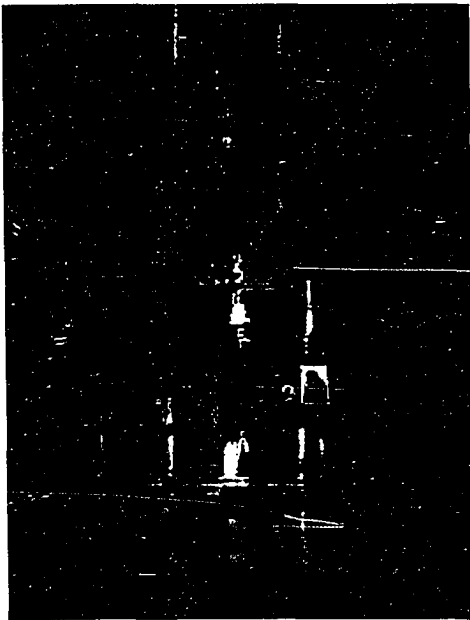


Fig. I.16 Gregoriou, Mount Athos. Spot of light moving onto holy gate.

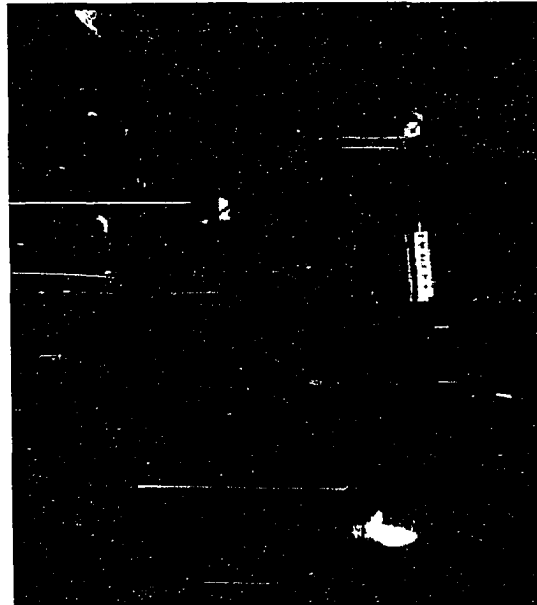
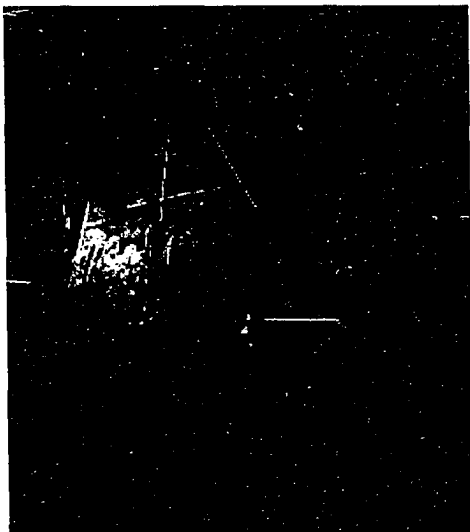


Fig. I.17 Gregoriou, Mount Athos. Spot of light climbing up the altar.

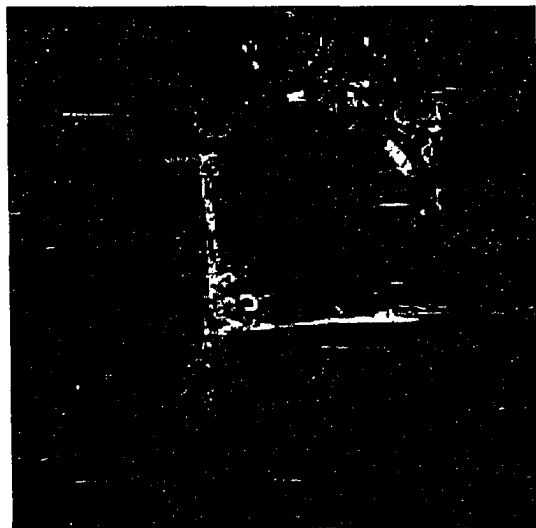
morning service in the church of Osiou Gregoriou (but also in other churches) diffuse light began illuminating the fresco of Mary's Dormition, placed on the western wall of the nave. This was later followed by a bright spot of sunlight which scanned the entire fresco. I was able to photograph this because of a break in the service (Figure I.18). It often happened during the morning service that a spot of sunlight illuminated one of the Evangelists located on the pendentives during the reading of the Gospel. This phenomenon was observed also during the Vespers in Vatopedi, Osiou Gregoriou and Megiste Lavra (Figure I.19).

In June of 1994, at the church of the Iveron monastery, I observed a shaft of light at about 9:10 A.M. coming through the southernmost window of the apse and directed precisely onto the altar. Before I was able to come back with my photographic equipment the shaft was obscured by a cloud. So the photograph does not show a clear shaft of light. (Figure I.20).

These striking examples served to suggest that the effects of manipulated light, which tended to impart a sense of the divine to the spectator, were most likely not acci-



*Fig. I.18 Gregoriou, Mount Athos.
Mary's dormition on W. Nave wall.*



*Fig. I.19 Vatopediou, Mount Athos. Shaft of light
slowly moving toward one of the Evangelists*

dental. The process of being exposed to and subsequently endeavoring to comprehend the way in which such effects may have been conceived and obtained led me to develop the theory which this dissertation seeks to substantiate.

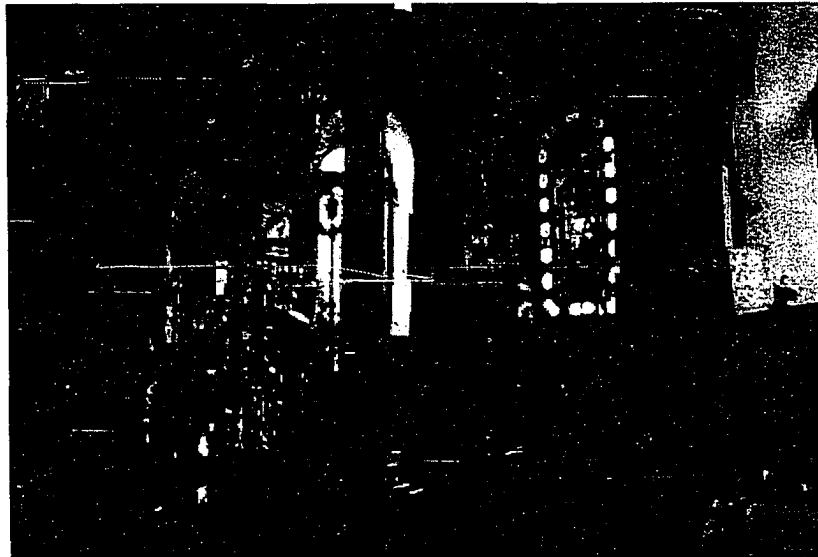


Fig. I.20 Iveron, Mount Athos. Light shaft from SE apse window onto the altar

Notes to Introduction

¹ Otto G. Von Simson, Sacred Fortress: Byzantine Art and Statecraft in Ravenna (Chicago: The University of Chicago Press, 1948): viii.

² See, for instance, a description of the humble monastery of St. Neophytos in Cyprus and the theatrical physical ascension of the Saint through a hatch in the middle of a fresco depicting Christ's Ascension in Heaven in Cyril Mango and Ernest J. W. Hawkins, "The Hermitage of St. Neophytos", Dumbarton Oaks Papers, 20, (1966): 205.

³ See a description of the imperial throne room and the use of automata to impress foreign ambassadors in Gerard Brett, "The Automata in the Byzantine 'Throne of Solomon'", Speculum, vol. 29 (July 1954), no. 3: 477-487.

⁴ For a description of the multiple visual effects employed in Hagia Sophia see Richard Krautheimer, Early Christian and Byzantine Architecture: 153-159. For a description of crosses in mosaic, glittering and visible throughout the church, see Thomas Whittemore, The Mosaics of Hagia Sophia at Istanbul v.I, (Oxford University Press for the Byzantine Institute, 1933): 12-28.

⁵ Data for another fifteen churches from Meteora, Mount Athos, Athens and Mistra had been stolen.

⁶ This perceived randomness is reflected in a study conducted by Yiannis D. Triantafyllides, Stoicheia Physikou Photismou ton Vyzantinon Ekklesion [Elements of Physical Lighting in Byzantine Churches] (Division of Antiquities and Restoration, Athens, 1964). In this study Professor Triantafyllides in attempting to understand the lighting conditions of certain Byzantine churches used a light meter to take systematic measurements of light intensity at predetermined locations within a number of Byzantine churches. In doing this he chose a time of day which did not interfere with the liturgy. His work, although valuable, acknowledges no relationship of the lighting conditions to the liturgical sequence.

⁷ Panayiotis A. Michelis, An Aesthetic Approach to Byzantine Art (London: B.T. Batsford, 1955): 27

⁸ The central chandelier is called "polyeleos" a term which stands for "merciful God," it has a conical form and is filled with tapers. There is a certain word-play involved here because the word "chandelier" corresponds to the Greek word "polyelaos" which stands for "with many oils" referring perhaps to the oil-based tapers that constitute it. The second chandelier has the form of a circle placed around the central one and consists of tapers alternating with small icons of Saints. This is called "The Chorus of Saints."

PART 1

THE HYPOTHESIS AND ITS CONTEXT

Introduction

The fundamental hypothesis of the dissertation, as outlined in the introduction, is that Byzantine religious architecture made conscious, systematic use of natural light for the experiential amplification of the liturgical act. Natural light constituted one of the most fundamental experiential components especially because of its potential for serving as a vehicle for apprehending the intelligible or “true” light of Divine origin. The role of light was to emphasize the truth of the Christian dogma and aesthetically draw the faithful into the Divine world. In order for this to be achieved the orientation and geometry of the church were manipulated. Light was made to shine on specific locations during liturgically significant times of day in order to intensify visually the message intended to be conveyed by the service. ¹

Within this overall lighting scheme certain phenomena are more readily discernible; three types of light effects observed in the churches on Mount Athos were identified. The first consists in a shaft of light shining on the Holy Sacraments at the time of their dedication to God. The second effect stems from the sense that the apex of the church dome often appears radiant with a light seemingly emanating from the representation of Christ Pantocrator, that usually occupies this position in domed church types. The third lighting effect consists in the sense that the central part of a domed Byzantine church operates as a “roofed spherical dial,” that is, a sundial in which the cast shadow that indicates the time of day has been replaced by a spot of light. ² This effect takes place in both a daily and a yearly cycle. Certain icons, frescoes, and mosaics which are of major significance to the liturgy tend to be found in locations that are highlighted daily by spots

of sunlight, while those of lesser importance may be highlighted once a year. This dissertation argues that these effects were guided by precise principles meant to evoke the unequivocal presence of the “true” light produced and distributed by God. According to this scheme, sunlight would shine through the windows illuminating the same spots at the same time and day of the year, for all time to come.

Such a complex system of designing in regard to the manner of admitting light into the church involved calculation of a number of factors in relation to one another, such as the altar position, the window dimensions, the successive sun positions throughout the day and year with special attention to Christian festival days, the form of the apse in plan, the timing method, the time of the dedication of the Holy Sacraments to God, the landscape formation, the position of the sun on the date of celebration of the dedicatory Saints, and the geometry of the dome relatively to the number and dimensions of the dome windows and window sills, to name a few. All these factors not only determined the orientation of the main axis of the church but also influenced the entire geometry of the church in plan and section. This suggests that the resulting system accounted for local differences in church orientation.

The liturgical sequence was related to the Byzantine method of time measurement. This method derived directly from the fact that the duration of daytime differs depending on the season and that time keeping relied on the use of sundials and water clocks. For this reason, the light effects designed for particular occasions and festivities around the year must be viewed in connection with both the timing method and the Julian calendar which was used in Byzantine times and is still observed today on Mount Athos. This calendar differs from the Gregorian which is in use today. Thus, the conditions in which the light effects would have occurred have to be geometrically reconstructed. As will be seen below, calculations of the kind described above were not beyond the capabilities of the better architects of that era. Moreover, adherence to tradition and the common practice of disseminating of church plans through central authorities,³ mini-

mized the demand that the actual builders of each church be aware of these fine aspects of the design.

This part of the study seeks to elucidate the historical context for the conceptions and manifestations that display a particular awareness of, and sensibility to, light. This section examines certain beliefs and tendencies in respect to notions of light in religion, philosophy, and the arts. The investigation of this general context proceeds with a detailed examination of the liturgical sequence and of the texts and canons used in the service as well as of interpretations of these texts and sequence provided by religious fathers and eminent clergy. Examination of these sources reveals the ways in which religious conceptions of the power and symbolism of light had crystallized within the rigid structure of canonical principles. The scope of this examination is confined to the study of the most fundamental part of the liturgy - the celebration of the Eucharist. This aspect of the liturgy is explored through primary and secondary texts in order to determine the significance and sequence of its basic functions. The liturgical functions are also examined in relation to the Byzantine method of time measurement in order to make explicit the relationships of the systems of time keeping, the succession of light phenomena and the liturgical sequence. Doing so is necessary because the Byzantine method of time measurement, with its direct dependence on the sun's motion and its impact on the daily church services serves to explain the interdependence of these systems and the nature of the architect's role in the church design. This is followed by a discussion of the architectural training of the period in order to suggest the degree of readiness and capacity of Byzantine architects to manipulate sunlight. Also included is an analysis of a particular geometrical problem, presented by Anthemius of Tralles in respect to its potential relationship to the basic thesis of the proposed study.

Notes to Part 1

¹ This hypothesis with corroborating data, included here in chapter 5, was presented in *The 28th Spring Symposium of Byzantine Studies* held at the University of Birmingham, in England in March 1994.

² See chapter 3

³ See paper by Professor Robert Ousterhout in which it is explained the way in which the proportions of Byzantine churches were derived, from a plan received from central authorities, by a system of ropes devised to secure the correctness of proportions during the time of construction. Professor Ousterhout refers to architectural practices followed in the post-iconoclastic period and his argument is based on hagiographic sources and manuscript illuminations. R. Ousterhout, "Byzantine Hagiography and the Art of Building," Abstracts of papers - 19th Annual Byzantine Studies Conference (New Jersey: Princeton University, 1993): 80-81.

CHAPTER I

NOTIONS ABOUT LIGHT IN RELIGION, PHILOSOPHY AND THE ARTS

Light was by no means an issue foreign to philosophical and religious thinking in the early Christian and Byzantine periods. In fact, it constituted a central subject in a critical theological debate that lasted for many centuries. Like most major religions, Christianity associated light with divine, spiritual, and metaphysical power. ¹ Ecclesiastical texts referred constantly to light. Its theological meaning seems to have been associated, particularly, with the Holy Spirit ² and with the vision of God or the expression of divinity. The liturgical acts and mysteries frequently involved light. The mystery of baptism, for instance, was thought to transform the initiated into *photisthentes* (i.e. illumined beings). ³ The Messiah was believed to be light and bring the light to humanity while Adam, according to the scriptures, was effulgent before he was banished from paradise. ⁴ Byzantine aesthetics, on the other hand, attempted to reach the ideal of an invisible world of which the material one was believed to be “the shadow.” ⁵ In this effort, the use of light became instrumental and went along with a strong interest in optics and perspective. ⁶

Light and the Parallels between Pagan Philosophy and Byzantine Thought

A great deal of mysticism seemed to permeate non-Christian philosophy in the first centuries A.D., while for Christian thinkers theology and philosophy had essentially merged. We shall discuss here briefly some concepts developed by Plotinus that are related to the issue of light and seem to have been taken up by the Fathers of the Church.

Plotinus (A.D. 204-70), the best known philosopher of this period is usually considered to be the founder of Neo-Platonism. ⁷ He was an idolater and a contemporary of Origen, the theologian. There is little literary evidence that Plotinus’s work was known to the Byzantines. ⁸ However, Plotinus’s work was highly esteemed by his contemporar-

ies⁹ and through the mediation of Pseudo-Dionysius (5th century) subsequent philosophical and religious inquiry became depended closely upon his thought and Christian thinkers were profoundly influenced by it.¹⁰ The Plotinian doctrine of the three hypostases, the One, the Intellect, and the Soul,¹¹ was composed into a treatise which had often been quoted by the Fathers of the Church.¹² Plotinus thought of himself not as a Neo-Platonist but as a Platonist; in other words, as an interpreter and follower of Plato. The main difference between Platonism and Neo-Platonism, according to Paul Henry, lies in that where Plato employs an ever inquiring dynamic method, Plotinus is rigid, tearing a small number of Platonic texts out of context and raising them into axioms in order to form a body of doctrine, thus turning dialectic into metaphysics dominated by mysticism.¹³ One can detect a natural kinship between the Christian and pagan spirituality of that period in Alexandria. Plotinus dealt (as Origen did) with the issue of flight from perceptible reality, which he equated to salvation and the vision of God.¹⁴

Porphyrus, his pupil and biographer, wrote about him:

Thanks to the illumination ascending toward the intellect . . . he saw God, who has neither form nor essence, since He lies beyond the intellect and beyond the comprehensible. The end and the goal for him was the internal union with God, who is above all.¹⁵

For Plotinus, ugliness was equivalent to shapelessness, to something that had not been mastered by pattern (which he equated to Reason), or to matter that had not yielded at all points and in all respects to Ideal-Form but that remained (outside of Reason and Idea and therefore) isolated from the Divine-Thought. He thought this Ideal-Form to be responsible for grouping, coordinating, and creating unities out of parts and he believed that a material thing could only become beautiful by communicating in the thought that flowed from the Divine.¹⁶ The beauty of color, for instance, was, for Plotinus, the outcome of a unification. It derived from shape, from the conquest of the darkness inherent in matter by the pouring-in of light, the unembodied (which he thought equal to the Rational-Principle and the Ideal-Form). He saw fire as being splendid beyond all material

bodies (holding the rank of Ideal-Principle), in contrast to the other elements, first, because of its ever upward tendency and its subtle and sprightly character (which came very near the unembodied) second, because it was able to penetrate most other bodies and give them warmth while this never became cold, and finally, because it had color primally and the splendor of its light belonged to the Idea. In the same vein, he considered all matter that had resisted the penetration of light as remaining outside of beauty.¹⁷

For Plotinus, then, beauty and light were closely intertwined. The distinction between ideal and material was equal to that between shapelessness and shape. At the same time, the kinship of light and fire was established, while the characteristics that brought both close to the ideal and the divine were thought to be their inexhaustible, primal, and penetrating power; a power that imparted a superior order to whatever did not resist its penetration. One also sees here the idea of communion with the divine thought as the way to approach beauty.

These ideas are quite akin to the recurring Byzantine association between life and light and between light and the immaterial element in material things. The Byzantines conceived of color, for instance, as light materialized.¹⁸ This characteristic Byzantine conception of the relation between color and light, and the Byzantine delight in the color of gold, are also found in Plotinus.¹⁹

All the loveliness of color and the light of the sun . . . And how comes gold to be a beautiful thing? And lightning by night and stars, why are these so fair?²⁰

In more general terms, the Neo-Platonic theory of aesthetic experience held that beauty is perceived aesthetically, that is by aisthesis, or the power of sensual perception. It is not reached by analytic or discursive reason but is apprehended by a sudden vision.²¹ In a parallel vein, many Byzantine religious writers thought that God could only be perceived by a sudden vision rather than by intellectual contemplation.

Plotinus also spoke of a beauty that transcended or was beyond the sense-bound life; such as the beauty of noble conduct, of learning, and of the virtues of justice and

moral-wisdom. These, he said, could only be known by the soul without any help from the organs. This vision was only for those who saw with the soul's sight and who rejoiced because by doing so they moved into the realm of truth.²² This beauty (which included qualities such as loftiness of spirit, righteousness of life, disciplined purity, courage of the majestic face, gravity, modesty, and fearless, tranquil and passionless character) was equated to the light of godlike Intellection. These, he wrote, were beautiful because they exist and they manifest to us their reality of Being and because grace and the splendor of Light rests upon them.²³ Again, concepts similar to the Plotinian "truth," "real being," "true light" became wide-spread among the Fathers.

Plotinus, also, declared that one must become purified and reach inner unity by being wholly true to his essential nature. Because if one succeeded in this, one would become veritable Light which is not measured by space, nor narrowed to any circumscribed form nor again diffused as a thing void of term, but is unmeasurable as something greater than all measure and more than all quantity. Only then one would be able to see the mighty or first Beauty, the uttermost brightness. The reason for this, he said, was that to any vision must be brought an eye adapted to what is to be seen, and having some likeness to it; because, never did eye see the sun unless it had first become sunlike, and never could the Soul have vision of the First Beauty unless itself be beautiful.²⁴ This again comes very near, as we shall see, to the foundations of Byzantine faith and the relation of the faithful to God that was accepted by Church dogma.

Light and the Nature of God

The theme of light had been a recurring one in the Old and New Testaments and continued to be so in the theological thought throughout the Byzantine era being as it were closely associated with the vision of God. The Bible abounds with references to light and divine revelations involving light. God, Christ, and the Holy Spirit have been seen as light.²⁵ It is often stated, however, that God could never be seen face to face;²⁶

that He tends to conceal Himself whenever He appears to unprepared men, for their own protection;²⁷ and that seeing God meant that one had become similar to him, that is, deified.²⁸

These ideas were later often embraced and slowly developed by theologians. The various divine qualities and the methods and means of seeing or attaining them constituted the subject matter of extensive and elaborate literary efforts and light became one of the most significant factors in these. It was conceived as one of the most essential qualities and an indispensable component of divine nature.²⁹ Christ, for instance, was often referred to as the “sun of righteousness.”³⁰ Fierce theological debates that lasted for many hundreds of years found their culmination in the concept that God was outside the categories of space and time³¹ and, therefore, inaccessible to humans in his essence.³² God could not be seen face to face³³ by anyone except by the Son and the Holy Spirit.³⁴ Based on this concept, it was believed that men could see God only through communion with His so-called “powers” or “energies” or “manifestations”³⁵ which were distinct from His essence (and were shared by all three hypostases of the Holy Trinity)³⁶ and which were often summed up as a certain kind of bright heavenly light³⁷ or fire.³⁸ Some writers claimed that this light was often seen through darkness³⁹ which was placed as an obstacle⁴⁰ or protection or served as a method of communication.⁴¹ This was often mentioned as “the indescribable or inexpressible light of the indivisible Trinity.”⁴²

This was called the “true” light, as opposed to the physical one, that had not been created by God (uncreated=aktiston) but it was thought to be preexisting and to constitute one of God’s properties. This light was thought to emanate from God⁴³ and to permeate those human beings that had become cleansed of sins and earthly thoughts and concerns⁴⁴ and had thus acquired a purified heart.⁴⁵ It was a light neither perceivable by the physical senses⁴⁶ nor comprehensible by the human mind⁴⁷ in this life but only after death.⁴⁸ It was thought that in the Second Coming the righteous would enjoy the king-

dom of heaven, which is nothing but a place filled with divine light.⁴⁹ Seeing God was believed to be equal to becoming a receptacle of light⁵⁰ and, thus, indestructible,⁵¹ incorruptible,⁵² and immortal.⁵³

God and his light could only be felt and seen fully and immediately by the whole being⁵⁴ through pure prayer,⁵⁵ and in proportion to each one's capacity or power.⁵⁶ This event could transpire only as a revelation with God's condescension or by divine grace.⁵⁷ It was believed that man had been created in the likeness of God but that he could become similar to Him and receive his light,⁵⁸ which is man's chief goal,⁵⁹ only with the aid, the enlightenment of, and the union with the Holy Spirit.⁶⁰ This could be achieved in two ways. First, by baptism⁶¹ and second, by the Eucharistic communion.⁶² According to some, enlightenment could also be achieved through intellectual knowledge⁶³ while for others, by opposition to knowledge.⁶⁴ The deification of man was thought equivalent to his partaking in the life of God which was, in turn, equivalent to the vision of light⁶⁵ or to being dressed in the light of the Father or of the Holy Spirit⁶⁶ and becoming luminous.⁶⁷

A celebrated and frequently cited example of such a revelatory participation in heavenly light was the event, described in the New Testament, of the Transfiguration of Christ on Mount Tabor during which the Apostles were enabled to see the divine light emitted by Christ.⁶⁸

The spermatic conceptions that led to these formulations had already been present, as already noted, in the Old and the New Testaments and they are found in forms not rigidly defined (or along with concepts that were later disposed of as heretic⁶⁹) in early Christian and early Byzantine times. These ideas, however, were further developed and precisely formulated in theological studies of subsequent periods (5th to 14th c.).

The clear distinction between the inaccessible and unknowable divine essence and the revelatory "powers," "energies" or "properties" becomes increasingly the characteristic of the proper or mainstream Byzantine theology. One of its most well known and

influential representatives is St. Dionysius the Aeropagite (5th c.) or so-called Pseudo-Dionysius.⁷⁰ He wrote that “the divine darkness corresponds to the inaccessible light in which God resides”⁷¹ and that the final goal is not the knowledge of the divine but the union with it which surpasses all intellect. One would be able to reach God only through ignorance and since God is incomprehensible one should try to know Him “supra-intellectually,” that is, without employing the intellect in a way that can be only taught by the Holy Spirit.⁷² Knowledge, he said, is limited to beings and since God is not a being⁷³ but the cause of all beings or rather is above any opposition between being and non-being, in order to unite with God one must step out of the realm of being.

According to Pseudo-Dionysius, God is not the One but the cause of unity as well as of multiplicity.⁷⁴ Multiplicity and unity also characterize the nature of the divinity itself. God has three hypostase but he also has “energies”⁷⁵ that are uncreated and which they are God himself but they are not His essence. They are many but they are essentially one; gleam, shine, light of the one essence of the most Holy and indivisible Trinity.⁷⁶ The divinity, says Pseudo-Dionysius, is fully revealed in these “energies.” The creations however, partake in these each in its own proportion according to its capacity and the order of the universe results from the diminishing degree in which each creation partakes of the divine energies. Thus, the creations ascend toward deification hierarchically ordered according to their illuminations eventually reaching supra-intellectually the unity with God.⁷⁷ Once this point has been reached one becomes surrounded by the radiance of the Trinity and partakes of it just like the one that shone on the apostles during the Transfiguration of Christ supra-intellectually. In this condition and thanks to this supernatural brilliant illumination, one is enabled to see the unity of the Holy Trinity which takes place beyond the intellect.⁷⁸

Pseudo-Dionysius exerted a great influence to Eastern theology but to the Scholastics of the West as well. In fact, a translation of his writings became the generative force for the creation of Gothic architecture in the 11th century in France. The first

Gothic church, initiated by abbot Suger, bears his name (St. Denis) as the patron-Saint because of Suger's admiration of him. Pseudo-Dionysius propagated the "anagogical approach" from the material to the immaterial world which became an inspiration for Suger. The name of this approach originates in the Greek word "anagomai" which means "I am being carried or conveyed higher or upward." A piece of Pseudo-Dionysius's work which is revealing of this approach is cited below:

Every perceptible thing, man-made or natural, becomes a symbol of that which is not perceptible, a stepping stone on the road to Heaven; the human mind, abandoning itself to the "harmony and radiance" which is the criterion of terrestrial beauty, finds itself "guided upward" to the transcendent cause of this "harmony and radiance" which is God. ⁷⁹

Pseudo-Dionysius reiterated in essence many of the ideas that had been expressed or were latent in earlier theological works. However, his work became influential because of its systematic character and great sweep.

St. Maximus the Confessor ⁸⁰ (580-662) was an admirer of Pseudo-Dionysius and introduced his work (*Corpus Dionysiacum*) into the mainstream of theological thought. His own writings and thought developed along similar lines.

Another great father of the Byzantine Church to whom reference should be made was St. John of Damascus (675-749). A theologian, poet, musician, and preacher, St. John accepted that God is unknowable in essence and that can be known only by revelation. His essence is beyond being and can be declared only by negations. Whatever affirmative is said about Him declares only His "manifestations," "powers," or "energies." ⁸¹ St. John makes a distinction between the divine and the human "energy" of Christ and he maintains that the holy body of Christ partook of the divine glory at all times. ⁸² Christ was transfigured, he said, not in order to receive something that He did not have but in order to show to His disciples what He was, ⁸³ to enable them to see the "energy," the light, of the divine glory. ⁸⁴ Because of the hypostatic union the human nature of Christ partakes of the divine glory and for this reason, he says, the flesh of Christ is life-generating, worthy of worship, and a source of divine grace and glory.

According to St. John, the Eucharist offers replicas of the holy body and blood of Christ not in the sense that they are not true but that while now one partakes of these as Eucharistic offerings, in the future eon one will partake of these solely through the vision of the divine glory. Thus, he says, partaking of the glory, those who did good deeds will shine like the sun through eternity. ⁸⁵

Along the same lines but following a much more simple and direct route is the teaching of St. Symeon the New Theologian (949-1022), who was abbot in the monastery of St. Mamas in Constantinople. He explained in his writings the ancient traditional prayer techniques of Hesychasm (a form of monastic life entirely dedicated to prayer and aiming at apathy). St. Symeon spoke of a revelation of the divine glory by means of the Holy Spirit within us which, in the higher levels of spiritual life, is revealed as light. St. Symeon says that this divine fire separates one from all visible or invisible beings and gives him the vision of the uncreated. ⁸⁶ For Symeon, God is light and transmits his brilliance to those who unite with him after they have undergone purification. He thinks this to be a miracle because the human unites with God both bodily and spiritually without having the soul be separated from the mind nor the body from the soul. ⁸⁷ The divine light is presented to the whole man as an uncreated reality which lies above spirit and matter. But it can also happen via a transformation of the created nature (of both body and spirit) through divine grace which appears as light into which the entire man partakes. For St. Symeon light means a meeting with God regardless of whether man rises toward God or God descends to man. God, as he says, does not reveal himself by any shape or imprint but simply as light without shape, incomprehensible, indescribable. ⁸⁸ This light is life-giving, ever-shining, it surrounds continuously every true Christian and it cannot be altered or turned away, it has no shape and turns into light those who are brightened by it. God is light and all those who succeeded to see or receive God, saw or received him as light. The light of His glory precedes Him and without light He cannot appear. Those who did not see His light did not see Him. Light is the Judgment and men

deserving can see this light before the Second Coming of Christ because the experience of this uncreated light presupposes an exit from the realm of time and space to the “mystery of the eighth day.” The Holy Spirit in the situation of deification of the future eon will appear to all simply as light.⁸⁹

Similar ideas appear to have been prevalent among the monks of Mount Athos who were practicing the techniques of Hysechasm. St. Gregory Palamas (1296-1359) became a monk on Mount Athos after he completed his studies in theology and philosophy. But in 1339 he came out of monastic life and in 1347 he became archbishop of Thessalonica in order to take part in a serious dogmatic conflict.

In 1339 the monk Barlaam of Kalavria attacked the hysechasts of Mount Athos ridiculing their ascetic habits and especially the insistence of some that they had experienced the uncreated light. Barlaam accused them as Messalianists (heretical sect that believed one could see God using his physical senses). Attempting to resolve the contradiction of inaccessibility of and potential access to the divine Palamas, at first, accepted this contradiction as a mystery and he claimed that there is, in fact, a distinction between the essence of God and his “energies” or “powers” and that while the essence is inaccessible, the partaking of men into His “energies” is possible.⁹⁰ Palamas refers to God’s “energy” as being a deifying brilliance and grace coming from within. God, he said, becomes known to those who, exceeding the limits of the created being, unite with him partaking of divine grace. “God is called light not in essence but in energy.”⁹¹ The “energies” are called light not only by analogy to physical light. During the contemplation of God the “energies” appear as an inexpressible reality the most appropriate name for which appears to be light. This light is given in a measure dependent on the virtue of each of those who experience it.⁹² The light seen by the apostles in Mount Tabor was the light of God, everlasting, infinite, indescribable in space and time, not part of created beings.⁹³ It appeared in the Theophanies of the Old Testament as “glory of God.” This is the light, Palamas said, that blinded Paul and was seen by Mary Magdalene during the

Resurrection⁹⁴ in which resided in the body of Christ and was seen by the Apostles because for an instant they came out of the categories of space and time and experienced the reality of eternity.⁹⁵ This light is neither perceptible, nor comprehensible but divine and uncreated.⁹⁶ He who partakes of the divine “energy” also becomes light to a certain extent. He unites with light and sees clearly what remains hidden to those that have not received this grace. So the just will be transformed by the divine light and will shine like the sun. These deified created beings will experience the blessing of the future eon through the uncreated light “of the outward shining secret splendor from the Tri-hypostatic Physis.”⁹⁷ He said that the divine Light is a prerequisite of mystical experience.⁹⁸

The Nature of Byzantine Religious Art

The issue of light, however, did not remain limited within the realm of theological-philosophical discourse; its influence and effect spread into the visual arts. Contemporaries of the early-Byzantine emperor Justinian (483-565), for instance, reasoned along lines that emphasized the spiritual connotations and dogmatic significance of light. Paul the Silentiary, Justinian’s court poet, in his poem about Hagia Sophia described Mary as

*...the Mother of Christ , the vessel of eternal Light.*⁹⁹

Because of its theological significance physical light - - including sunlight, moonlight, and the various forms of artificial and pictorial light- - assumed symbolic, metaphorical, and didactic functions as a vehicle for the comprehension of “true” light and the attainment of salvation. Many of the principles and concepts that were developed by religious writers, and were later established as the approved dogma by the Church found expression in the iconographic representations that decorated church walls. These representations constitute one of the richest available sources for the study of Byzantine art. Apart from their availability, however, they are particularly valuable to our study because they reveal certain attitudes that also permeated the architectural design of the church

viewing it as a model of an invisible divine world.

Church iconography did not constitute a decorative art for the embellishment of churches separated from preaching or the liturgical acts and mysteries that took place within the church. In fact, the opposite was true. It was a strictly liturgical art. Especially, after Iconoclasm it was decreed that the decoration of the church had to be dictated clearly by liturgical and doctrinal reasons. The Church, based on the decision of the 7th Ecumenical Synod, ¹⁰⁰ took, officially, the responsibility to direct iconography and to impose a hierarchical order to the iconographic subjects. The goal was to provide a visual aid that would facilitate and compel a communication of the substance of the events that were taking place before the eyes of the faithful. To this end, detailed depictions of important events derived from the Scriptures were composed following certain manners, methodologies, and expression suitable to the subject matter and their liturgical function. The frescoes or mosaics that occupied entire walls of the church served the purpose of religious instruction following the most suitable subjects from preaching. In an effort not only to represent scriptural subject matter but also to teach and convince the faithful, Byzantine iconography borrowed methods deriving from rhetoric. Certain rhetorical techniques, found in the works of the fourth-century Fathers, such as vivid description, eulogy, and the heightening of emotion became particularly attractive. The Fathers introduced these forms of rhetoric into the mainstream of Greek Christian literature, and these eventually passed from literature into art. ¹⁰¹ According to St. John of Damascus, “images are the books of the illiterate;” ¹⁰² and Pseudo-Dionysius, referred to the objects that make up the visible world of the senses acting as reflections of the invisible world of the spirit. ¹⁰³ St. John of Damascus elaborated on this idea:

... the invisible things of God . . . are seen and apprehended in created things. We see images in creation which faintly reveal to us the reflections of God, as when, for instance, we speak of the Holy and eternal Trinity imaged by the sun, or light, or a ray . . . ¹⁰⁴

St. John also stated that the illustration of metaphors reflecting the world of the

spirit should be the Byzantine artist's aim. ¹⁰⁵

What is of particular interest here is the significance of iconography, its spatial organization and the manner and conventions employed in its visual expression examined with the objective of establishing the role of light in them. This encompasses the manner and loci where pictorial light is implemented, the potential analogies between the pictorial and architectural implementation of light as well as the actual physical relationship of architectural light and iconographic representations.

According to patriarch Germanus, the church, the place where the faithful convene, has the meaning of "heaven on earth within which the Heavenly God dwells and walks about." ¹⁰⁶ Pseudo-Dionysius (5th c.) believed that the church should be considered the type and image of the heavenly church. ¹⁰⁷ This is something that had to become perceived by the multitudes of people coming into the church in the most palpable manner. For this reason, everything in the church had been ordered in ways that evoked symbolically and aesthetically this fundamental image. This encompassed not only the various objects and images but also the ordering of time, space, and light.

The Iconographic Cycles

Initially, the position of the images did not follow a fixed hierarchical order. ¹⁰⁸ After Iconoclasm the iconographic subjects, constituting three iconographic cycles, are placed each in a fixed position in the church. These cycles are the dogmatic, the liturgical, and the historical (feastal) and the positions of the subjects are determined by the symbolic meaning which acquire, now, the main parts of the church.

1. The Dogmatic Cycle

After Iconoclasm the iconography is officially characterized as dogmatic, that is, its content aims to express the dogmatic truth. The dome becomes the image of heaven, the floor becomes the image of the earth. Christ Pantocrator is represented in the dome, while the prophets who foresaw the Savior follow on the drum below. The four evangelists who by their preaching supported the teaching of Christ are depicted on the

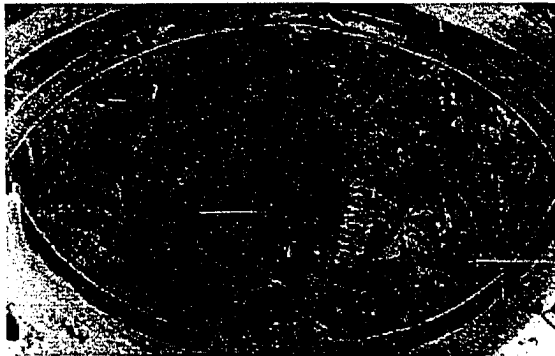


Fig. 1.1. Christ as Apollo, within a brilliant "glory", Os. David, Thessaloniki



Fig. 1.2 Pantocrator in dome. Dafni Athens

pendentives. In the quarter-sphere of the apse of the Bema is placed the Theotokos Platytera (Theotokos Wider than the Heaven-because she contained the uncontainable) who united heaven and earth. On the drum of the gate through which one enters from the narthex into the nave is represented the bust of Christ (Christ-teacher, "the Gate") or Christ-enthroned with the founder of the church kneeling before him. These subjects of Pantocrator, Platytera, and Christ as Gate constitute the dogmatic cycle. ¹⁰⁹

The representations of Christ from early on incorporate certain stylized and symbolic forms of pictorial light. Early representations of Christ show him as Apollo, young and beautiful, beardless, "god of light" (Fig. 1.1). ¹¹⁰ Often this is combined with a brilliant "glory" or a representation of an opening through which a star-studded, deep blue sky and sometimes a cross is seen (Fig. 4.15). ¹¹¹ Often a radiant Christ is placed within this blue painted "opaion" or "occulus" (Fig. 4.14). ¹¹² The representation of Christ as Apollo, however, was later discontinued because it was thought to be inappropriate. The Byzantine Pantocrator, became now "at once the Father and the Son," the expression of the doctrine of one essence. But he was also the Creator, the Savior and the Judge and he had to be seen directly with one of these properties. ¹¹³ So, he was shown with the royal majesty of the Creator, the expression of the active goodness of the Savior, and the

severity of the impartial Judge. See, for instance, the Pantocrator of Dafni (Fig. 1.2). The expression of suffering, severity, and divine kindness are emphatically articulated in his face. In the dome, rising at the center of the church and in the crossing of the vaults, the triumphal figure of Christ Pantocrator dominates, dazzlingly illuminated by the brilliant light which enters through the windows of the drum (Fig. 1.3).

The doctrine of Virgin Mary as being “actually Theotokos” (Having Given Birth to God), a dogmatic truth established by the Ephesian Synod (431), is expressed by the depiction of the Mother of God holding Jesus as child in the quarter-sphere of the apse.
¹¹⁴ The two are usually surrounded by two archangels (Fig. 1.4). This quarter-sphere, with the rest of the conch, is the architectural part which unites the roof of the church and the ground, the upper (dome), i.e. the heaven, with the lower, i.e. the earth, the floor of the church on which the faithful are found. So, the Mother of God stands between heaven and earth, as “the one who mediated the salvation of mankind,” as “the heavenly stair through which God descended,” as “the one who joined the upper with the lower” through the Divine Child in her lap. ¹¹⁵

At the entrance of the church, “the Royal Gate,” Jesus as “Gate,” ¹¹⁶ that is, Jesus as Teacher ¹¹⁷ receives the faithful. This is an image of him on the drum of the gate, in



*Fig. 1.3 Round perforations of window panels direct the light.
 Dome windows, Dafni, Athens*



Fig. 1.4 Lavra, Mount Athos. The Mother of God with archangels Michael and Gabriel

which he is represented frontally, blessing and carrying the Gospel on which the inscription “I am the Gate,” or “I am the light of the world” is usually found.¹¹⁸ See, for example, the mosaic of Hagia Sophia of Constantinople.¹¹⁹ (Fig. 5.90)

2. The Liturgical Cycle

In the Bema the, so-called, liturgical cycle unfolds. As it is explained by the Fathers of the Church, the Eucharist is of capital importance because the gathering of the faithful mainly takes place for the experiencing of this event. This teaches about the salvation that is found only in Christ and the way in which the partaking in the “Christ’s Altar” is performed. Around this circulate the prayers, the hymns and the sermon. The liturgical action of the priest is conceived as a repetition of the one performed in Heaven by Christ. The iconography was placed at the disposal of this goal of the Church thus becoming a liturgical art. It sought to contribute to the comprehension of the great mystery of the

divine Eucharist and of the entire liturgical drama by the faithful. The liturgical themes of the Communion of the Apostles, the Liturgy of the Angels, of the Hierarchs Celebrating Mass together before Christ, and the older, like Abraham's sacrifice etc. determine the liturgical iconographic cycle (Fig. 1.5, 1.6) ¹²⁰

When the Church beckon the faithful who "the Cheroubim mystically portray" to "repel all life concerns" in order to receive the King of all, around whom the angelic orders hover invisibly, the iconography comes to assist experientially toward making conscious this invitation of the Cherubic Hymn. The ideal figures of the angels, who come in awe, bringing presents to the Lord and the apostles, being entirely shattered and in piety, come to receive communion from His pure hands, make discernible by the senses the content of the hymn and induce, through their spiritual atmosphere, its comprehension. A good example is the fresco of the Peribleptos in Mystra. Here, the lean



Fig. 1.5 Lavra, Mount Athos. Transp. of the Ark, Divine Liturgy

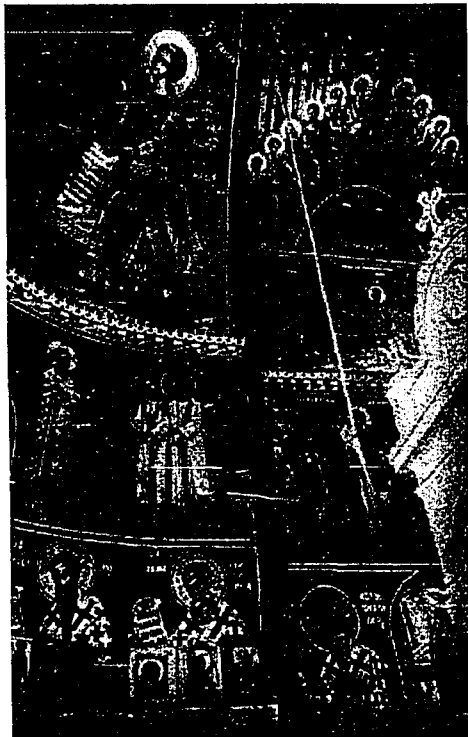


Fig.1.6 Lavra, Mount Athos. Apse, Archangel Gabriel Pentecost, Divine Liturgy

figures of the angels, who in a rhythmic majestic procession carry the Holy Gifts in fear and terror covering their faces before the most sublime Sacrifice, offer the viewer, through the achieved de materialization, the impression of a vision from another world, make discernible by the senses the content of the liturgical hymn “Let all consumable flesh be silent and stand in fear and terror and think of nothing earthly.”¹²¹

In the barrel-vault before the apse is depicted the apocalyptic scene of the Preparation of the Throne, a representation which is later placed at the center of the scene of the Pentecost which has a circular form. The preparation illustrates the first and the Second Coming of Christ showing the empty Throne of Judgment and the instruments of the Christ’s Passion.¹²²

In other cases, the Ascension is depicted in this area (Fig. 1.7), One may observe here once again the brilliant “glory” surrounding Christ. Of liturgical character are also the representations in the apse of Abraham’s sacrifice, of Melchisedek, of Aaron as well as of



Fig.1.7 Vatopedi, Mount Athos. St. John the Evangelist on NE pendentive and Ascension on E barrel vault

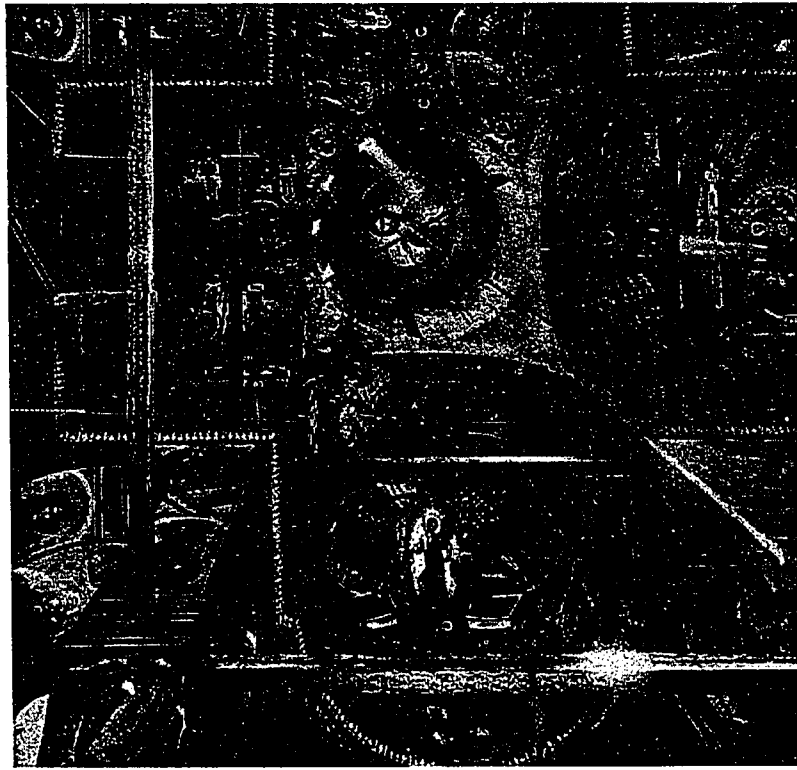


Fig.1.8 Docheiariou, Mount Athos. View of the cupola and barrel vaults with the Dodecaorton

the great hierarchs and the deacons, of the Daniel and the three children. We also see here the representation of Christ as Lamb, which later evolves into the Melismos (Dismemberment), that is, into the depiction of the Lord as infant on the plate (diskarion) referring to the sacrifice of the lamb which is performed by the priest on the altar.¹²³ The faithful, however, after the introduction of the iconostasis in the 12th century were unable to see these images.

3. The Historical (Feastal) Cycle

The subjects of Byzantine iconography do not simply concern the religious history, but are organized according to the theology of the Church.¹²⁴ The third cycle, the historical or feastal, develops on the four barrel-vaults and the sidewalls of the nave and in the narthex. In the barrel-vaults the scenes of the life of Christ, that is, the Dodecaorton (Twelve Feasts) are placed (Fig. 1.8). Thus, the main events of the entire

life of the Lord (which include the Nativity, Baptism, Circumcision, Crucifixion, Resurrection, Ascension) are depicted, revealing the theology of the plan of redemption, and creating the feeling that one is dominated by the sacred symbol and is covered by the “Sign of the Lord,”¹²⁵ within which the entire Christian teaching is contained and expressed.¹²⁶ This reveals to the faithful the Christ’s presence on earth in its entirety. All that is taught through the Liturgy, through the ecclesiastic hymns and the words from the ambo, is thus underlined by silent images. By their placement within the barrel-vaults is ensured that the scenes of the life of Christ, receive no direct but only reflected light. For this reason certain windows are placed high on the nave walls so that their sills can serve as light-shelves or reflectors (Fig. 5.8). This is in accord with the doctrine that Christ is self-luminous, that He emits light from within, and that He is the “true light” of the world.

Two examples are included here in order to indicate the importance of the detailed depiction of the dogmatic truth in either a literal or metaphoric sense. In most representations of the Nativity, Theotokos and the divine infant are placed in the middle of the composition while Joseph is placed far away in order to show that he had taken no part at



Fig. 1.9 Dafni, Athens Nativity

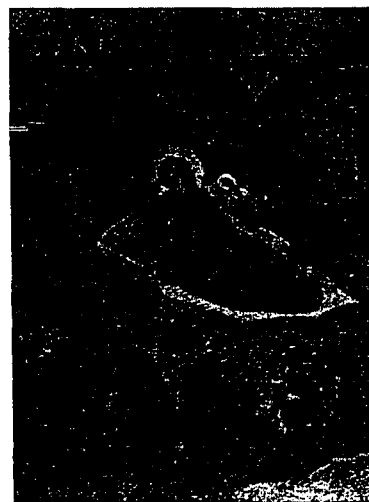


Fig. 1.10 Nativity icon kept in Lavra, Mount Athos



Fig.1.11 Vatopedi, Mount Athos. Baptism on upper part of barrel vault

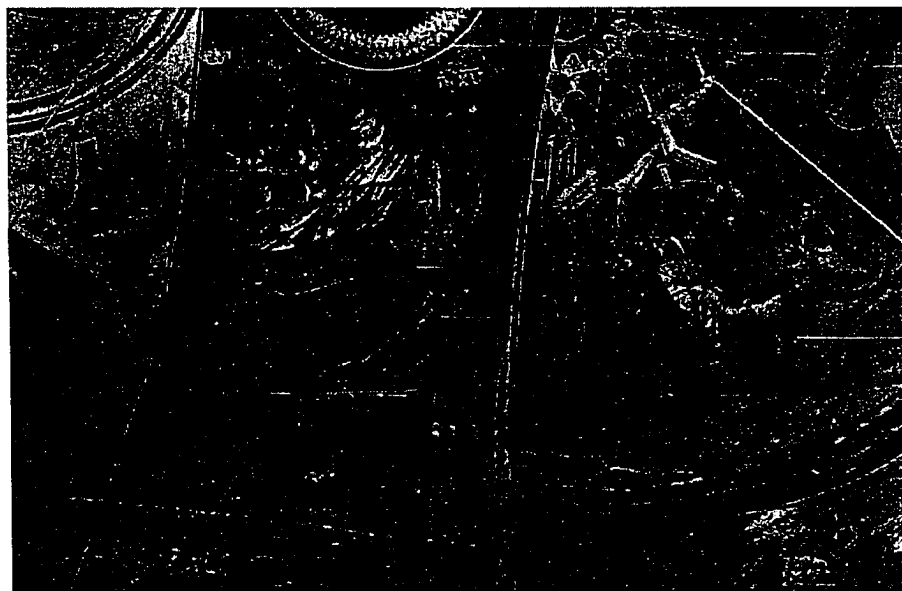


Fig.1.12 Vatopedi, Mount Athos, Saint Mathews, Nativity of Christ, Baptism

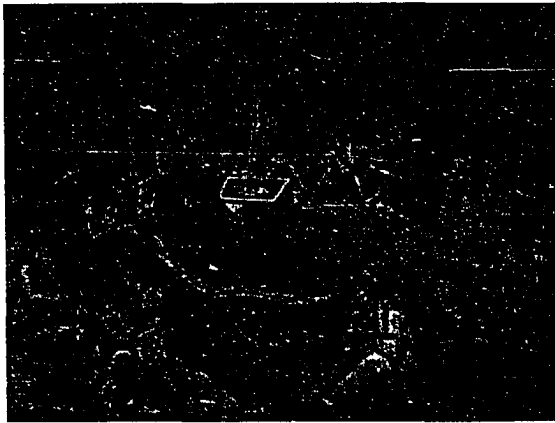
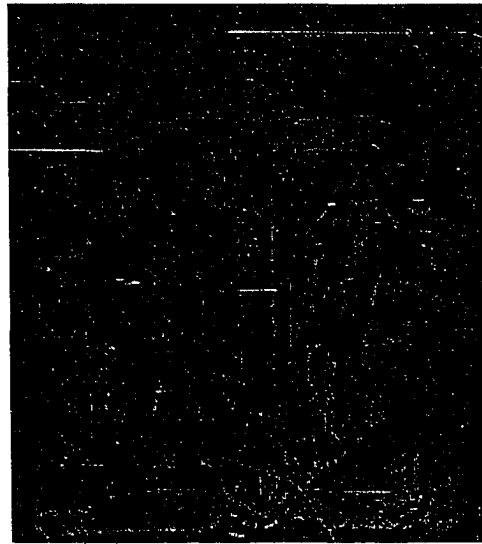


Fig. 1.13 Chora, Istanbul, Nativity



*Fig. 1.14 Santa Maria Antiqua, Rome.
Christ dead but with eyes open.*

all in the Incarnation (Fig. 1.9, 1.10, 1.12). Theotokos is shown lying at the top of a mountain formed before the cave symbolizing her virginity as “mountain unquarried” according to the Acathistos Hymn. In many representations of the Crucifixion, on the other hand, the face of Christ is shown with a collected royal majesty, calmness, and serenity. Through these, instead of the pain and the suffering, the theological concept of the “Completed Sacrifice” on the Cross is expressed.

According to Orthodox dogma, the flesh of the Lord did not undergo any decay, therefore, Christ’s body was depicted unaltered from death. A calm inclination of the head and the closed eyes were considered adequate indications of death. In fact, originally, the Crucifixion was depicted with Christ’s body dead but with his eyes vividly open (Fig. 1.14) because first, according to Eastern dogma Christ suffered as a man but His divine nature remained apathetic ¹²⁷ and second, the body of God did not lose the fervor of life even in death. It underwent decomposition, i.e. separation of the soul from it, but not decay, degeneration, sepsis.

On the side walls hierarchs, saints and holy martyrs are depicted while in the

western wall, from the narthex side, is placed the composition of the Second Coming. The decoration in the narthex is later extended with the monks and the founders in which scenes from the apocrypha and the life of Mary are placed. With these representations the historical cycle is completed.

It is made clear in the writings of the Fathers that the Church is interested in the beauty of the transcendental world. But since that world cannot be represented but only expressed, this kind of iconography does not represent its subjects but only expresses them. Its content is not the physically beautiful or good. In Byzantine art what is good is not determined by the physical form of an object, but by its sublime content, that is, by its power to serve the ideals of faith. This is characteristically stated by John the Chrysostom:

a device, an animal, or a plant we consider as good not because of its configuration, nor because of its color, but because of its ministry. ¹²⁸

Byzantine iconography did not copy neither did it aim at the configuration or the color, but it employed abstractly those technical and artistic elements that were necessary in order to impel the appropriation of its spirit and dogmatic concepts by the faithful. ¹²⁹



Fig. 1.15 Chora, Istanbul. Descent to Hades

As a result, the faces of the heavenly world are represented in a different way than those still living in the present world, and yet differently from those that are deprived of the spirit and the grace. To the first ones is ascribed infinite spirituality by the subtraction of volume and weight, those elements, that is, that are reminiscent of matter. Observe, for instance, the representation of the holy-martyrs and the women-saints in the mosaics of St. Apollinaire the New in Ravenna ¹³⁰ in contrast to the mosaics of the escort of Justinian and Theodora, in St. Vitale in Ravenna. ¹³¹ The large eyes and noses, the vivid outlines, the frontal positions of the saints and the rest of the vivid and exceeding actual measure, features interpret the intense psychic life of those represented. The frontal positions of the saints denote the direct link between them and the faithful. ¹³² The large eyes and inquiring glance of Christ in addition to the ruggedness and powerful character of the features render the princely character and the highly spiritual nobility of his figure. ¹³³

The various representations are placed in distinct zones. The lower zones depict monks and lower ranking martyrs or saints while in the upper zones one finds saints and angels placed higher in the hierarchy. However, it appears that this placement is not solely driven by a conventionally symbolic aim. But that it becomes underlined aesthetically by an expressive symbolism as well. First, figures that are not in the present life acquire features that are stylized and that do not remind one of an actual portrait. Second, the faces acquire more inner pictorial light the higher they are found in the hierarchy and certain features that denote intense spiritual life become more intensified. Third, those figures that are more endowed with the “true light” are found in higher areas of the walls where only reflected (Heavenly) light can reach them (Fig. 1.23) while those of lower inner illumination are found in places where direct (worldly) sunlight comes in contact with them.

Light was the symbol of life, of joy and of resurrection ¹³⁴ and was exalted every Sunday in the reveille gospel, the ainoi, the doxastika, the whole liturgy - - delineating



*Fig.1.16
Vatopedi, Mount
Athos.
Transfiguration*

the resurrective character of the iconography. ¹³⁵

In the pictorial sense, light is implemented in a number of different ways. In the Descent to Hades ¹³⁶ (Fig. 1.15), in the Ascension (Fig. 1.7) in the Transfiguration (Fig. 3.19, 1.16, 1.17, 1.20) in the Dormition of Mary (Fig. 1.19a,b) Christ is depicted within an area in the form of a polygon, ellipse, or rough circle of bright light often referred to as “divine glory.” This serves to denote, first, that He is entirely steeped in the uncreated “energy” of the Father and second, that he is spatially separated from the figures that are placed within conventional space. This background of enveloping light, within which no lines or objects of conventional space can be detected, distances Christ from adjacent figures. He is with them but He also lies outside the category of space and, therefore, of being. Also, the color of this light is usually bright-white denoting its ethereal nature by



Fig.1.17 Lavra, Mount Athos. The Transfiguration

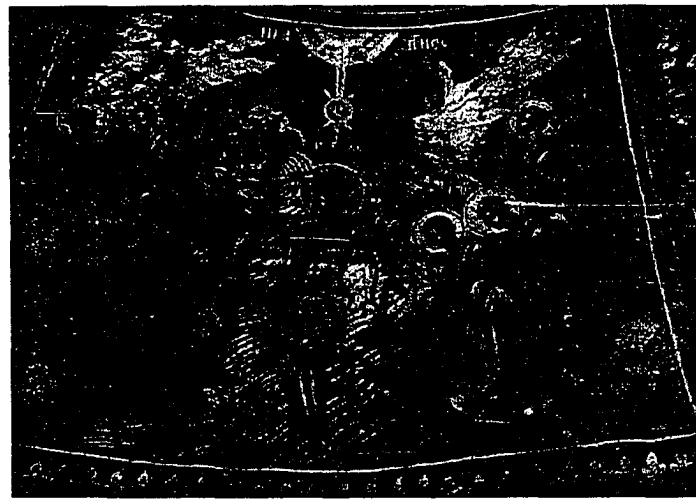


Fig.1.18 Lavra, Mount Athos. Jesus and John, Baptism

being dissimilar to the yellowish light of the sun.

A second kind of pictorial light is that of the light poured onto Christ during Baptism stemming from the Holy Spirit (Fig. 1.18, 1.11, 1.12, 1.21, 1.22), which is depicted as a white dove. Also the light of the star of Bethlehem sends out shafts of light in much the same fashion, perhaps in a little more direct manner than the Holy Spirit (Fig. 1.9, 1.13). This method of directed light signifies the selective and revelatory action of God who disperses His light "to whomever, and however He wishes."



Fig.1.19a Lavra, Mount Athos. The Dormition of Mary



Fig.1.19b Lavra, Mount Athos. The Dormition of Mary, detail

A third kind of pictorial light is that emitted by various figures from within, these figures have received light. Because of their purity they are depicted as partaking in the light of God, which still resides within them. The light, emitted from within, eliminates the effects produced by physical light shining on their faces, canceling out the shadows created by physical light and transposing material forms and facial features. These effects also seem to impact a certain uniformity to the whole face while eliminating the reality, materiality, and distinct character of the faces obtained from the shadows cast by the configuration of the flesh and bone-structure in each individual face (Fig. 1.23). Also see



Fig. 1.20 Dafni, Athens. Transfiguration

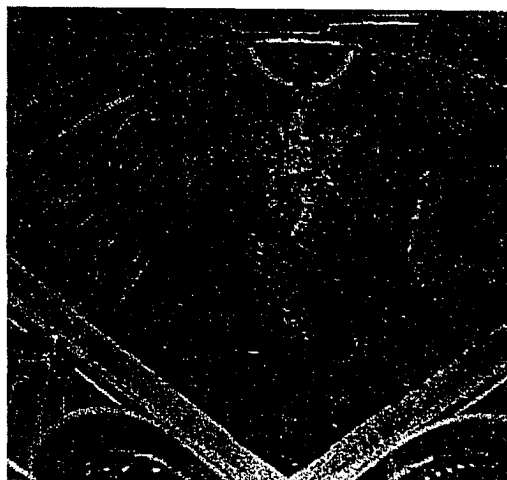


Fig. 1.21 Osios Loukas, Steiri Boiotias. Baptism

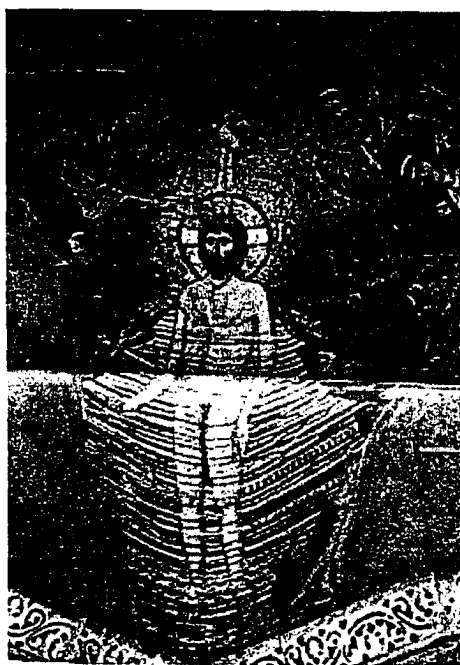


Fig. 1.22 Dafni, Athens. Baptism



Fig. 1.23 Chora, Istanbul. The inner light in Virgin Mary and Christ, mosaic



Fig.1.24 Lavra, Mount Athos. The Dormition of Mary, Detail

the difference between the three men and Mary (Fig. 1.24). Referring to the mosaic of Christ as Gate in the central lunette of the narthex of Hagia Sophia of Istanbul

Whittemore writes:

... he (the artist) permitted himself to illuminate the throne from either side and was indifferent to momentary aspects of light and shade. His task, as he understood it, was to escape from phenomena, and by rejecting the accidents of time and space, to obtain a timeless rendering; to pass from appearance to the ideal reality behind it and establish a presentation of the permanent that is hidden from the unreflective mind.¹³⁷

Thus, the iconographic cycles intertwine but are also distinct. The dogmatic cycle is concentrated in three locations that mark the main points of the course of the eye both in the horizontal and the vertical direction. From Christ the Gate, to the Pantocrator and to Virgin Mary the eye moves horizontally and axially, while, from Christ the Gate to the Virgin Mary and to the Pantocrator, it moves upward. From an architectural standpoint, these locations are illuminated not by direct, but only by reflected light. The liturgical cycle is concentrated within the apse. Here the general illumination level is higher than in the rest of the church, the dome excepted. The apse, although spatially belonging to the church, is set apart as being outside of space and time because of its brilliant illumination. This is due to the high density of light streaming in through the windows facilitated by the significant slanting of the window reveals and sills. This brilliant cool light becomes equivalent to the pictorial light of the glory that envelops Christ and sets him apart in frescoes, when He is represented among earthly beings. Finally, the historical cycle is spread throughout the church. It is lit by a general, usually dim ambient light while certain locations become the focus of light from time to time. A correspondence, therefore, appears to exist between the iconographic cycles and the expressive quality of both the pictorial and architectural light.

Notes to Chapter I

- 1 Mircea Eliade, The Two and the One, (London: Harvill Press, 1965): 62
- 2 Ibid.
- 3 Ibid.: 57
- 4 Ibid.: 59
- 5 A' Corinthians 13, 13, 13 Patrologia Graeca 82, 336D.
- 6 Gervase Mathew, Byzantine Aesthetics (London: John Murray, 1963): 1
- 7 Ammonius Saccas (175-242) is considered by others to be the founder of Neo-Platonism. Originally Christian he became an apostat. Origen, Plotinus, Errenius, Longinus were his students.
- 8 Mathew, Byzantine Aesthetics : 19-20.
- 9 Plotinus and Origen were both students of Ammonius Saccas and they held each other at high esteem and there was considerable exchange between the two. Porphyrios, Peri Plotinou Viou [About the Life of Plotinus] chapter 14 (Vivliotheke Papyrou 172): 70. See also Porphyrios, Vita Plotini.
- 10 Paul Henry in Plotinus, The Enneads, transl. S. MacKenna, (New York: Penguin Books, 1991): xliii-xlv.
- 11 Ibid.: 5, 1 "On the Three Principal Hypostases"
- 12 Such as Eusebius of Caesarea, Basil, Augustine, Cyril, and Theodoret. Ibid.: liii, also 5, 1, 8; 5, 1, 10;. Also see E.R. Dodds, "The Parmenides of Plato and the Origin of the Neoplatonic One", in Classical Quarterly xx (1928): 129-42. Also see Porphyrios, Vita Plotini, 25, 32.
- 13 Plotinus, The Enneads: xlvii-xlviii.
- 14 Ibid.: 1, 6, 8: 53-4 (Beauty); 6, 9, 11 (On the Good, or the One)
- 15 Porphyrios, Peri Plotinou Viou : 94.
- 16 Plotinus, The Enneads,: 1, 6, 2 (Beauty)
- 17 Ibid.: 1, 6, 3 (Beauty)
- 18 Mathew, Byzantine Aesthetics: 5.
- 19 Plotinus, The Enneads, 1, 6, 2 (Beauty); 1, 6, 3 (Beauty)

20 Ibid.: 1, 6, 1 (Beauty)

21 Ibid.: 1, 6, 2 (Beauty)

22 Ibid.: 1, 6, 4 (Beauty)

23 Ibid.: 1, 6, 5 (Beauty)

24 Ibid.: 1, 6, 9 (Beauty)

25 The face of God is the light of salvation. Psalms 79, 4, 20; 4, 7; 30, 17; 67, 2; 79, 4; 20, 7; God will open someone's eyes to the light Isaiah 42, 6-7; God as light Isaiah 60, 1-3; 9, 2; Psalms 26, 1; God as the sun of righteousness Malachias 4, 2; The light of God substitutes the sun Isaiah 60, 19-20; Apocalypse 21, 23-24; 22, 5; Christ or God with clothes of light Mark 9, 3; Psalms 103, 2; Daniel 7, 9; Matthew 17, 2; Luke 9, 29; Christ or God as light and true light Matthew 4, 16; 17, 5; Luke 1, 78-79; 2, 30-32; John 1, 4-9; 8, 12; 9, 5; A' Epistle of John 1, 5-7; 2, 8; Acts of the Apostles 13, 47; B' Peter 1, 19; Psalms 118, 105; Isaiah 49, 6; Christ as brilliant sun Matthew 17, 2 Apocalypse 1, 16; The face of Moses shone from the reflection of the glory of the face of God. Exodus 34, 29; "Because we do not speak that which we did not know but we declare that which we witnessed, that the light already became visible in darkness." John 1, 5; References to God and Christ as fire or fiery eyes Apocalypse 1, 14; 2, 18; 4, 5; 19, 12; God bright as precious stone Apocalypse 4, 3; Even important representatives are presented in this light. Angel in cloud with a halo on his head his face bright like the sun, his legs like steles of fire. Apocalypse 10, 1; Angel with great power and with shining glory Apocalypse 18, 1; Baptism in Holy Spirit and fire Matthew 3, 11; Mark 1, 8; Luke 3, 16; John 1, 33; Acts 1, 5; Communication of Christ with the Spirit of God in the shape of the dove after baptism Matthew 3, 16; Mark 1, 10; Luke 3, 22; John 1, 32; Christians as the light of truth Matthew 5, 14; The Holy Spirit descends like fire on the third hour of the Pentecost Acts of the Apostles 2, 1-15; God is revealed through the Holy Spirit. A' Epistle to Corinthians 2, 8-14; Epistle to Romans 8, 1-17;

26 Only the Son and the Holy Spirit can see God. John 5, 19-20 and A' Corinthians 2, 20; Apostle Paul said: "God, the only one having immortality; he who resides in light; whom no man has seen or is able to" A' Timotheon 6, 16. God said to Moses: "You will not be able to know my face; for no man can know my face and remain alive" Exodus 33, 20-23. This is stated in other passages as well. Judges 6, 22; 13, 22; Isaiah 6, 5. "Noone has ever seen God." A' Epistle of John 4, 12; John 1, 18. God is seen, known, explained, and revealed only by Christ. John 1, 18; 6, 46; Matthew 11, 27; Luke 10, 22;

27 God appeared to each prophet in a different way. Osieih, 12, 11; When God "within a dark cloud" descended at Sina "in fire" the people had to remain at a distance so that many of them do not die. Exodus 19, 21. God elapses his glory while with the right part of it covers Moses who is inside a hole of a stone. Exodus 33, 22; When God withdrew his hand Moses saw his behind, but was unable to see his face. Exodus 33, 23. God as fire and darkness Deuteronomion 4, 11; When God appeared before him, Eliah covered his face with his sheepskin. C' Kings 19, 13; "He was placing darkness before him to hide himself." Psalms 17, 2; This darkness denotes the presence of God. Numbers 12, 5; Psalms 98, 7; 103, 3; Isaiah 19, 1; Naoum 1, 3; Deuteronomion 33, 26; Exodus 16, 10; 19, 9; Leuitikon 16, 2; Iob 22, 11; Daniel 7, 13; etc. The stele of cloud and fire that was marching before the Hebrews when they came out of Egypt at once revealed and concealed the presence of God. Exodus 13, 21; 14, 19; Deuteronomion 31, 15; Neemias 9, 12. God concealed in darkness Exodus 19, 9-25; 24, 9-18; 33, 11-23;

34, 4-8; Deuteronomion 5,4; References to God or Christ as a cloud or within clouds Mark 9, 7; Apocalypse 1, 7; 14, 14; Psalms 103, 3; Matthew 17, 5; Luke 9, 34-5;

28 “We know that if he appears, we will be similar to him, because we will see him as is.” A’ John 3, 1-2; “Because we see now as on a mirror something puzzling. But then we shall see face to face. Now I know only in part, then I will know as perfectly as Christ knew me.” A’ Corinthians 13, 12;

29 St. Gregory the Theologian or the Nazianzen (328-390) in “Logos” [Speech] 16, 9 Patrologia Graeca 35, 945C.

30 St. Cyrillus of Alexandria (370-444) in “Eis ton Malachian” [To Malachian] chapter 44, 2-3, Patrologia Graeca 72, 360AC;

31 Didymus the Blind (313-393) in “Peri tis Agias Triadas” [About the Holy Trinity] B’ Vivliothiki Hellinon Pateron [Library of Greek Holy Fathers] 43, 211, 9-13; B’ Chapter 4, 43, 222, 40 - 223, 2; B’ Chapter 1, 43, 210, 17 - 212, 27. St. Gregory the Theologian or the Nazianzen (328-390) in “Logos” [Speech] 16, 9 Patrologia Graeca 35, 945C. St. Diadochos (5th c.) in “Orasis” [The Envisioning] “E. des Places. Diadoque de Photice: Oeuvres Spirituelles” in Sources Chretiennes 5 bis (Paris, 1955): 173.

32 Didymus the Blind, “Peri tis Agias Triadas” [About the Holy Trinity] 43, 211, 9-13; B’ Chapter 4, 43, 222, 40 - 223, 2; B’ Chapter 1, 43, 210, 17 - 212, 27. St. Gregory the Theologian, “Logos” [Speech] 28, 4 Patrologia Graeca 36, 32. St. Gregory of Nyssa (335-399) in “Eis tous Makarismous” [On Beatitudes] 6, Patrologia Graeca 44, 1269A. St. Epiphanius of Cyprus (315-403) in “Panarion” [Panarion] C, Chapter 70, 7-8 Patrologia Graeca 42, 349 - 353A. St. John the Chrysostom (344-407) in “Eis to kata Ioannin” [On Saint John’s], 1. Theodoretos of Cyrou (393-453) in “Eranistis” A, Patrologia Graeca 83, 45C. St. Diadochos (mid 5th century) in “Logos Askitikos 57” [Ascetic Speech 57] Filokalia [Love of Goodness] Vol.1, 257;

33 Clements of Alexandria (150-215) in “Stromateis” E, 11 Vivliothiki Hellinon Pateron 8:143, 4-6.

34 St. John the Chrysostom (344-407) “Eis to kata Ioannin” [On Saint John’s] IE, 1.

35 Clements of Alexandria “Stromateis” E, 12 Vivliothiki Hellinon Pateron 8:147, 2-3; E, 11, 8:142, 16; E, 11, 8:142, 17-18. Didymus the Blind “Peri tis Agias Triadas” [About the Holy Trinity] B’ Chapter 1 Vivliothiki Hellinon Pateron 43, 211, 9-13; Bø, Chapter 4, 43, 222, 40 - 223, 2; Bø, Chapter 1, 43, 210, 17 - 212, 27. St. Basil the Great (330-379) in “Epistoli pros Amfilohion” [Letter to Amfilohios] 234, 1 in Y. Courtonne, St. Basile Lettres tom. III (Paris 1966):42. Also “Peri tou Agiou Pneumatou” [About the Holy Ghost] A, 6 Patrologia Graeca 29:521-4; 6, 31:344B; Cø, 5, 29:665 BC; THø, 23, 32:109. St. Gregory of Nyssa “Eis tous Makarismous” [On Beatitudes] 6, Patrologia Graeca 44, 1269A.

36 Didymus the Blind “Peri tis Agias Triadas” [About the Holy Trinity] B’ Chapter 1 Vivliothiki Hellinon Pateron 43, 211, 9-13; Bø, Chapter 4, 43, 222, 40 - 223, 2; B’, Chapter 1, 43, 210, 17 - 212, 27.

37 Ibid. 43, 211, 9-13; Bø, Chapter 4, 43, 222, 40 - 223, 2; Bø, Chapter 1, 43, 210, 17 - 212, 27. Euagrius the Ponticus (345-399) in “Epistoli eis Melanian” [Letter to Melanian] 619; and in “Ekatontas” [Hundredth] 1, 35

- 38 St. Gregory of Nyssa (335-399) in “Peri Viou Moyseos” [About the Life of Moses] Patrologia Graeca Also see Ioannou Romanidou, Dogmatiki and Symboliki Theologia tis Orthodoxou Katholikis Ekklisias [Dogmatic and Symbolic Theology of the Orthodox Catholic Church] (Thessaloniki, 1973) 1:81-82. St. Macarius the Egyptian (4th c.) in “Omilia” [Speech] 25 chapter 9 Vivliothiki Hellinon Pateron 41, 271, 16 - 272, 7
- 39 St. Gregory the Theologian, “Logos” [Speech] 32, 16 Patrologia Graeca 36, 193.
- 40 Ibid.: 28, 4 and 36, 32.
- 41 St. Gregory of Nyssa “Peri Viou Moyseos” [About the Life of Moses] Patrologia Graeca. Also Ioannou Romanidou, Dogmatiki and Symboliki Theologia tis Orthodoxou Katholikis Ekklisias [Dogmatic and Symbolic Theology of Orthodox Catholic Church] (Thessaloniki, 1973) 1: 81-82.
- 42 St. Gregory the Theologian or the Nazianzen (328-390) in “Logos” [Speech] 28, 4 Patrologia Graeca 36, 32. Ibid. 16, 9 Ibid. 35, 945C. Euagrius the Ponticus (345-399) in “Ekatontas” [Hundredth], Ibid. 7, 2; and in “Peri Proseuhes” [About Prayer] 150 Filokalia [Love for Goodness] 1, 189; “Ekatontas” [Hundredth] 6, 56; “Antirritikos Logos” [Speech in Opposition]; and in “Ekatontas” [Hundredth] 3, 6; Euagrius the Ponticus (345-399) in, Epistoli eis to Melanian” [Letter to Melanias] 619; and in “Ekatontas” [Hundredth] 1, 35; Makariou the Egyptian “Omilia” [Speech] 2 chapter E Vivliothiki Hellinon Pateron 41, 155; Ibid. 5 chapter D 177, 22-26.
- 43 Euagrius the Ponticus, “Epistoli to Melanias” [Letter to Melanias] 1, 35;
- 44 St. Gregory the Theologian, “Logos” 16, 9 Patrologia Graeca 35, 945C.
- 45 Clements of Alexandria, “Stromateis” Z, 11 Vivliothiki Hellinon Pateron 8:277, 16-22; E, 1, 8:110, 18-19. Origen (185-255) in “Peri Arhon” [About Principles] B’ 11, Patrologia Graeca 240-248. St. Gregory of Nyssa, “Eis tous Makarismous” [On Beautitudes] 6, Patrologia Graeca 44, 1269A. Euagrius the Ponticus, “Ekatontas” [Hundredth] 7, 2;
- 46 St. Theophilos of Antioch (2nd c.) in “Pros Autolykon” [To Autolykos] A’ chapter 2 Vivliothiki Hellinon Pateron 5:13, 18 - 14, 20 & chapter 7 v. 5:16, 35-38. Didymus the Blind “Peri tis Agias Triadas” [About the Holy Trinity] B’ Chapter 1 Vivliothiki Hellinon Pateron 43, 211, 9-13; Bç, Chapter 4, 43, 222, 40 - 223, 2; Bç, Chapter 1, 43, 210, 17 - 212, 27.
- 47 Ibid. 43, 211, 9-13; Bç, Chapter 4, 43, 222, 40 - 223, 2; Bç, Chapter 1, 43, 210, 17 - 212, 27. St. Basil the Great (330-379) in “St. Basil’s the Great letter to Amfilohios” 234, 1 in Y. Courtonne, St. Basile Lettres tom. III (Paris 1966):42. Also “Peri tou Agiou Pnevματος” [About the Holy Ghost] A’, 6 Patrologia Graeca 29:521-4; 6, 31:344B; C’, 5, 29:665 BC; TH’, 23, 32:109. St. Gregory the Theologian, “Logos” 28, 4 Patrologia Graeca 36, 32. St. Gregory of Nyssa (335-399) in “Eis to Asma Asmaton” [On the Song of Songs] IB’, Patrologia Graeca 44, 1028A. St. Diadochos (mid 5th century), in “Orasis” [Envisioning] 14-15 “E. des Places. Diadoque de Photice: Oeuvres Spirituelles” in Sources Chretiennes 5 bis (Paris, 1955):173
- 48 Clements of Alexandria (150-215) in “Paidagogos” [Educator] A’, 6 Vivliothiki Hellinon Pateron 7:97, 9-12;

49 St. Macarius the Egyptian (4th c.) in “Omilia 17” [Speech 17] Chapter D Vivliothiki Hellinon Pateron 41, 244, 6-9; and in “Omilia 34” [Speech 34] Chapter B’ Vivliothiki Hellinon Pateron 41, 312, 32-33; St. Diadochos, “Orasis” 14-15 “E. des Places. Diadoque de Photice: Oeuvres Spirituelles” in Sources Chretiennes: 173

50 Euagrius the Ponticus, “Ekatontas” [Hundredth] 3, 6; St. Macarius the Egyptian, “Omilia 2” [Speech 2] Chapter E Vivliothiki Hellinon Pateron 41, 155; and in “Omilia 5” [Speech 5] Chapter D Vivliothiki Hellinon Pateron 41, 177, 22-26; and in “Omilia 4” [Speech 4] Chapter IB’ Vivliothiki Hellinon Pateron 41, 163, 1-3;

51 Holy martyr Eirenaïos (2nd c.) in “Kata Ereseon D” [On Heresy D] 20,2 Patrologia Graeca v.7: 1033B.

52 Athanasius the Great (295-373) in “Logos peri tis Ensarkoseos tou Logou” [Speech on the Incarnation of Reason] Chapter 4 Vivliothiki Hellinon Pateron 30, 78, 25-28; and in Chapter 43, 30, 110, 23-29.

53 Holy martyr Eirenaïos (2nd c.) in “Kata Ereseon D” [On Heresy D] 20,5 Patrologia Graeca v.7:1035AB; also 20, 6 Patrologia Graeca v. 7: 1036A. St. Macarius the Egyptian (4th c.) in “Omilia 25” [Speech 25] Chapter 9-10 Vivliothiki Hellinon Pateron 41, 271, 16 - 272, 7

54 Euagrius the Ponticus (345-399) in “Ekatontas” [Hundredth] 7, 2; St. Macarius the Egyptian (4th c.) in “Omilia 2” [Speech 2] Chapter E’ Vivliothiki Hellinon Pateron 41, 155; and in “Omilia 5” [Speech 5] Chapter D’ Vivliothiki Hellinon Pateron 41, 177, 22-26; and in “Omilia 4” [Speech 4] Chapter IB’ Vivliothiki Hellinon Pateron 41, 163, 1-3

55 nticus, “Ekatontas” [Hundredth] 7, 2; and in “Peri Proseuhas” [On Prayer] 150 Filokalia [Love for Goodness] 1,189; “Ekatontas” [Hundredth] 6, 56; and “Logos Antifatikos” [Contradictory Speech]; St. Diadochos, “Logos Askitikos” [Ascetic Speech] 57 Filokalia [Love for Goodness] 1, 257.

56 St. Cyrillus of Jerusalem (315-386) in “Katihisis” [Catechism] Z.11 Vivliothiki Hellinon Pateron 39, 88, 33-34; ST’, 2, 39, 87, 6-11. and in “Katihisis” ST.6 Vivliothiki Hellinon Pateron 39, 105, 27-31. St. Epiphanius of Cyprus (315-403) in “Panarion” C, Chapter 70, 7-8 Patrologia Graeca 42, 349 - 353A. St. John the Chrysostom (344-407) in “Peri tou Akataliptou” [On the Incomprehensible] D, 4 Patrologia Graeca 48, 474E.

57 Holy martyr Eirenaïos (2nd c.) in “Kata Ereseon” [On Heresy] D’ 20,5 Patrologia Graeca v.7, 1034-5. Clements of Alexandria, “Stromateis” E, 12 Vivliothiki Hellinon Pateron 8:147, 2-3; E, 11, 8:142, 16; E, 11, 8:142, 17-18. St. Basil the Great, “Letter to Amfilohion” 234, 1 in Y. Courtonne, St. Basile Lettres tom. III (Paris 1966):42. Also “Peri tou Agiou Pneumatou” [On the Holy Ghost] A’, 6 Patrologia Graeca 29:521-4; 6, 31:344B; Cç, 5, 29:665 BC; THç, 23, 32:109. St. John the Chrysostom, “Peri tou Akataliptou” [On the Incomprehensible] D’ 4 Patrologia Graeca 48, 474E. St. Cyrillus of Alexandria, “Eis to kata Ioannin” [On Saint John’s] I, Patrologia Graeca 74, 286C; St. Macarius the Egyptian, “Omilia 25” [Speech 25] Chapter TH-I Vivliothiki Hellinon Pateron 41, 271, 16 - 272, 7; St. Diadochos, “Logos Askitikos 89” [Monastic Speech 89] Filokalia [Love for Goodness] v. 1, 226

58 Euagrius the Ponticus, “Epistole pros Melanian” [Letter to Melanias] 619; and “Ekatontas” [Hundred] 1, 35; St. Macarius the Egyptian, “Omilia 7” [Speech 7]

5-6 Vivliothiki Hellinon Pateron 41, 188, 28-33; and in “Peri Eleutherias Noos, Logos” [Speech on the Freedom of the Mind] Chapter 22 Vivliothiki Hellinon Pateron 42, 247, 5-6; St. Diadochos, “Logos Askitikos 89” [Ascetic Speech 89] Filokalia v.1, 226

59 Clements of Alexandria, “Stromatis” B, 22 Vivliothiki Hellinon Pateron v. 7:355, 37-38; B, 10, v. 7: 325, 14-16. Origen (185-255) in “Peri Arhon” [On Principles] C’ 6, 2 Vivliothiki Hellinon Pateron 11: 328, 36-40; “Peri Arhon” [On Principles] C’ 6, 3 Patrologia Graeca 11:356C-356A; Based on the scriptures Kollasaeis 3, 11. Genesis 1, 26. A’ Corinthians 6, 17; “Peri Arhon” [On Principles] A, 3, 8 Patrologia Graeca 11:155B.

60 Holy martyr Eirenaïos (2nd c.) in “Peri Ereseos” [On Heresy] E’, 6, 1 Patrologia Graeca v.7, 1138. Athanasius the Great (295-373) in “Peri tis Ensarkou Epifanias” [On the Incarnation of Epiphany] Chapter 8 Vivliothiki Hellinon Pateron 33, 226, 4-5. and “Pros tous Episkopous Aigyptou kai Libuis” [To the Bishops of Egypt and Libya] Chapter 1 Vivliothiki Hellinon Pateron 31, 220, 18-21. St. Basil the Great (330-379) in “Epistole pros Amfilohion” [The Letter to Amfilohion] 234, 1 in Y. Courtonne, St. Basile Lettres tom. III (Paris 1966):42. Also “Peri tou Agiou Pneumatou” [On the Holy Ghost] A’, 6 Patrologia Graeca 29:521-4; 6, 31:344B; C’, 5, 29:665 BC; TH’, 23, 32:109. St. Gregory the Theologian, “Logos” [Speech] 16, 9 Patrologia Graeca 35, 945C. St. Cyrillus of Alexandria, “Eis to kata Ioannin” [On Saint John’s] IA, Patrologia Graeca 74, 541D; “Thisauros Logos” [Treasure Speech] LD, Patrologia Graeca 75, 597C; “Eis to kata Ioannin” [On Saint John’s] IA, Patrologia Graeca 74, 545A and in “Eis to kata Ioannin” [On Saint John’s] I, Patrologia Graeca 74, 286C; St. Cyrillus of Alexandria, “Eis to kata Ioannin” [On Saint John’s] D’, 2, Patrologia Graeca 73, 572D; St. Macarius the Egyptian, “Omilia 7” “Omilia 7” [Speech 7] 5-6 Vivliothiki Hellinon Pateron 41, 188, 28-33; and in “Peri Eleutherias Noos, Logos” [Speech on the Freedom of the Mind] Chapter 22 Vivliothiki Hellinon Pateron 42, 247, 5-6; and in “Omilia 2” [Speech 2] Chapter E Vivliothiki Hellinon Pateron 41, 155; and in “Omilia 5” [Speech 5] Chapter D Vivliothiki Hellinon Pateron 41, 177, 22-26; and in “Omilia 4” [Speech 4] Chapter IB Vivliothiki Hellinon Pateron 41, 163, 1-3;

61 St. Cyrillus of Alexandria (370-444) in “Glafora is tin Exodon” [Refinements on Exodus] 11, Patrologia Graeca 69, 432A; St. Diadochos (mid 5th century) in “Logos Askitikos 89” [Asceteci Speech 89] Filokalia v. 1, 226;

62 St. Cyrillus of Alexandria (370-444) in “Eis to kata Ioannin” [On Saint John’s] D’ 2, Patrologia Graeca 73, 572D;

63 Clements of Alexandria, “Stromateis” D’ 22 Vivliothiki Hellinon Pateron v. 8:97, 1-2; Z, 10, v. 8:270, 33-37. Origen (185-255) in “Peri Arhon” [On Principles] D’ 36, Patrologia Graeca 11:411D-412A; and B, 11, Patrologia Graeca 240-248; Many of his ideas and arguments were condemned by the 5th Ecumenical Synod. See Ioannou Romanidou, Dogmatiki and Symboliki Theologia tis Orthodoxou Katholikis Ekklesias : 75

64 St. Cyrillus of Alexandria, “Eis to kata Ioannin” [On St. John’s] D’ 2, Patrologia Graeca 73, 572D; Euagrius the Ponticus, “Ekatontas” [Hundredth] 7, 2; St. Diadochos, “Logos Askitikos 57” [Ascetic Speech] Filokalia v. 1, 257

65 Holy martyr Eirenaïos (2nd c.) in “Peri Ereseos” [On Heresy D] 20,5 Patrologia Graeca v.7: 1035B. St. Gregory the Theologian or the Nazianzen (328-390) in “Logos” [Speech] 16, 9 Patrologia Graeca 35, 945C. and in “Agion Baptisma” [Holy Baptism] 41 Patrologia Graeca 36, 417C. St. Cyrillus of Alexandria (370-444) in “Eis to

kata Ioannin” [On Saint John’s] IA , Patrologia Graeca 74, 541D; “Treasure Speech” LD’ , Patrologia Graeca 75, 597C; “Eis to Kata Ioannin” [On Saint John’s] IA , Patrologia Graeca 74, 545A. St. Cyrillus of Alexandria, “Eis Malachian” B, Chapter. 44, (D’ 2-3) , Patrologia Graeca 72, 360AC; St. Macarius the Egyptian, “Omilia 7” [Speech 7] 5-6 Vivliothiki Hellinon Pateron 41, 188, 28-33; and in “Logos peri tes Eleutherias tou Noos” [Speech on the Freedom of the Mind] Chapter 22 Vivliothiki Hellinon Pateron 42, 247, 5-6; and in “Omilia 25” [Speech 25] Chapter TH-I Vivliothiki Hellinon Pateron 41, 271, 16 - 272, 7; and in “Omilia 2” [Speech 2] Chapter E Vivliothiki Hellinon Pateron 41, 155; and in “Omilia 5” [Speech 5] Vivliothiki Hellinon Pateron 41, 177, 22-26; and in “Omilia 4” [Speech 4] Chapter IB’ Vivliothiki Hellinon Pateron 41, 163, 1-3; and in “Omilia 30” [Speech 30] Chapter D Vivliothiki Hellinon Pateron 41, 299, 34-38;

66 Holy martyr Eirenaïos, “Kata Ereseon D” [On Heresy D] 20, 2 Patrologia Graeca v.7: 1033B. St. Macarius the Egyptian “Omilia 12” [Speech 12] Chapter A Vivliothiki Hellinon Pateron 41, 205, 29-35;

67 St. Diadochos, “Logos Askitikos 89” [Ascetic Speech 89] Filokalia v. 1, 226; and in “Logos Askitikos 40” [Ascetic Speech 40] Filokalia v. 1, 246;

68 St. Gregory the Theologian “Logos 32”, [Speech 32], 16 Patrologia Graeca 36, 193. St. Macarius the Egyptian “Logos 25” [Speech 25] Chapter TH-I Vivliothiki Hellinon Pateron 41, 271, 16 - 272, 7;

69 Such as Origen’s (185-255) idea that the Holy Spirit was subordinate to Christ and Christ to the Father, in “Erminia eis to kata Ioannin Euaggelion” [Interpretation of St. John’s Gospel] v. B’ Chapter 6, 10 Vivliothiki Hellinon Pateron v. 11: 297-298; or Eunomius’s (4th c. Arianist) teaching that the Son was subordinate and dissimilar to the Father while the Holy Spirit was one of the Father’s created energies; or his ideas of the comprehension of God by means of an “objective name” that fully described His logical content - in “Apologitikos” [Apologetic] Chapter 23-25 Patrologia Graeca 30, 860A-861D; Or the belief of Theodoret of Cyrou (5th c.-Nestorianist) that the vision of God is limited to the vision of the human nature of Christ - in “Eranistis” A’ Patrologia Graeca 83,52B, 48B; and the Messalianist (a sect condemned by a Synod in 383) belief that the essence of God is visible with the physical eyes.

70 St. Dionysius the Aeropagite was a disciple of apostle Paul and second bishop of Athens. In the 6th century several writings circulated bearing his name. The name of the author is not thought to be authentic but the actual name of the author is not known. Thus, he is referred to as Pseudo-Dionysius or St. Dionysius the Pseudo-Aeropagite. Pseudo-Dionysius is considered to be one of the greatest religious authorities. Ceslas Pera. Dénys le Mystique et la Théomachia in Revue des Sciences Philosophiques et Théologiques (1936): 62.

71 Saint Dionysius the Aeropagite, “Epistoli 5 Dorotheo” [Letter 5 to Dorotheos] Patrologia Graeca 3, 1073A.

72 Saint Dionysius the Aeropagite “Peri ton Theion Onomaton” [On the Holy Names] Chapter 2,1 Patrologia Graeca 3, 867A; “Peri tis Mistikis Theologias” [On the Secret Theology] Chapter 1,3 Patrologia Graeca 3, 1001A;

73 Ibid.: 1,1 Patrologia Graeca 3, 588B;

74 Ibid.: 13,3 Patrologia Graeca 3, 981;

75 Pseudo-Dionysius calls these “energies” also “projections,” “emissions,” or “powers.”

76 Saint Dionysius the Aeropagite “Peri ton Theion Onomaton” [On the Holy Names] Chapter 2,11 Patrologia Graeca 3, 648B;

77 Ibid.: 1,4 Patrologia Graeca 3, 641-644;

78 Ibid.: 1,4 Patrologia Graeca 3, 592BC;

79 Pseudo-Dionysius in Erwin Panofsky, Meaning in the Visual Arts, (Chicago: The University of Chicago Press, 1982): 128.

80 St. Maximus was secretary of the emperor Heraclius. Later he became a monk. He is one of the greatest Fathers of the Orthodox Church. See Saint Maximus the Confessor, “Amfivallomena” [Dubious Matters] Patrologia Graeca 91, 1392AD; see also his Mystagogy.; see also Saint Maximus the Confessor, “Peri Agapis Ekatontas” [Hundredth On Love] 3, 98 Filokalia v.2, 40, 26, 17

81 Ioannis Damaskinos, “Ekdosis Akrivis tis Orthodoxou Pisteos” [Accurate Publication Of the Orthodox Faith] Chapter 4, Patrologia Graeca 94:800C.

82 Ioannis Damaskinos, “Logos eis tin Iperendoxon Metamorfosin tou Kuriou imon Iisou Christou” [Speech on the Glorious Transfiguration of our Lord Jesus Christ] Chapter 12, Patrologia Graeca 96: 564B.

83 Ibid.: 12, Patrologia Graeca 96: 564C.

84 Ibid.: 13, Patrologia Graeca 96: 565BC.

85 Ioannis Damaskinos, “Ekdosis Akrivis tis Orthodoxou Pisteos” [Accurate Publication Of the Orthodox Faith] Chapter 4, 27, Patrologia Graeca 94:1228A.

86 Symeon the New Theologian “Logos Poietikos 1” [Poetic Speech 1] Ta Apanda [The Complete Works] (Thessaloniki, 1969) V. 2:1

87 Ibid.: 1:135

88 Ibid.: 1: 516; “Logos Poietikos 45” [Poetic Speech 45], 10, v. 1:230

89 Ibid. 57, 4, v. 1:294; “Logos 79” [Speech 79], 2, v.1:431-2; “Logos 57” [Speech 57], 2, v. 1:289; “Logos 27”, v.2:40; “Logos 52”, 1, v. 1:264. C. Mango, Byzantium: The Empire of New Rome (London: Weidenfeld & Nicolson, 1980):119; see also “Treatise on Confession” in K. Holl, Enthusiasmus und Bussgewalt beim Griechischen Monchtum (Leipzig, 1898):110ff.

90 Gregorios Palamas, “Kefalaia 69” [Chapters 69] Filokalia v.4:159; 121, v.4:176; Theofanis, chapter 20:246, 18-19; Chapter 17:243, 21; Vol. Conference 1351 chapter 9 in Ioanni Romanidou, Dogmatiki and Symboliki Theologia tis Orthodoxou Katholikis Ekklisias [Dogmatic and Symbolic Theology of Orthodox Catholic Church]: 281-336.

91 Gregorios Palamas, “Kata Akindinou Antirritikos 6” [Speech 6 in Opposition to Akindynos] Chapter 9 in Pan. Christou, Gregoriou Palama Syggramata

[Writings of Gregory Palama] (Thessaloniki, 1962): v.3:397

92 Gregorios Palamas, "Omilia 35 Eis tin Autin tou Kuriou Metamorfosin" [Speech 35 On the Transfiguration of the Lord] Patrologia Graeca 151,428CD.

93 Ibid.: 34, Patrologia Graeca 151,428CD.

94 Gregorios Palamas, "Kefalaia 67" [Chapters 67] Filokalia v. 4:158,

95 Saint Gregorios Palamas, "Omilia 35 Eis tin Autin tou Kuriou Metamorfosin" [Speech 35 On the Transfiguration of the Lord] Patrologia Graeca 151,429A. Saint Gregorios Palamas, "Kata Akindinou Antirritikos 4" [Speech 4 in Opposition to Akindynos] Chapter 1 in Pan. Christou, Gregoriou Palama Syggramata (Thessaloniki, 1962) v. 3:279, 18-19.

96 Saint Gregorios Palamas, "Agioireitikos Tomos" [Volume on the Holy Mount Athos] Chapter 6 in Pan. Christou, Gregoriou Palama Syggramata (Thessaloniki, 1962)v.2:575,25 - 576,10.

97 Gregorios Palamas, "Omilia 35 Eis tin Autin tou Kuriou Metamorfosin" [Speech 35 On the Transfiguration of the Lord] Patrologia Graeca 151,448D. Also see Ioannou Romanidou, Dogmatiki and Symboliki Theologia tis Orthodoxou Katholikes Ekklesias [Dogmatic and Symbolic Theology of Orthodox Catholic Church] : 226-256. Also, Patrologia Graeca v.151: 448B, 429A, 448D

98 Saint Gregorios Palamas, "Kata akindinou Antirritikos 4" [Speech 4 In Opposition to Akindynos] Chapter 21 in Pan. Christou, Gregoriou Palama Syggramata v.3:281,23; 282, 29.

99 William R. Lethaby & H. Swanson, The Church of Sancta Sophia Constantinople. A Study of Byzantine Building (New York:Macmillan and Co., 1894): 47

100 "The making of the images is the invention of the painters, but in relation to this of . . . the Church is the eminent responsibility of making the rules and keeping tradition . . . Of these (the Fathers) the contrivance . . . and not of the painter; because of the painter the art only, while the arrangement obviously of the Holy Fathers." Mansi, Sacr. Consil. Nova et Ampl. Collectio, XIII, 252

101 Henry Maguire, Art and Eloquence in Byzantium (Princeton, NJ: Princeton University Press, 1981): 20.

102 John of Damascus, Patrologia Graeca, 94: 1265D.

103 E. Kitzinger, "The Cult of Images in the Age before Iconoclasm," Dumbarton Oaks Papers, 8 (1954): 137ff.

104 John of Damascus, Patrologia Graeca 94: 1241BC.

105 Maguire, Art and Eloquence in Byzantium : 10

106 Patriarch Germanos, Patrologia Graeca, 98: 384.

107 Patrologia Graeca, 3 : 369.

108 Konstantinos Kalokyres, He Zografike tes Orthodoxias [Painting in the Orthodox Faith] (Thessaloniki: Ekdoseis Pournara, 1972): 46.

109 Ibid.: 65-7.

110 See the examples of the mosaic of the Julius tomb in the Vatican Necropolis (third century) Ibid.: 44. Also see English translation, K. Kalokyres, The Essence of Orthodox Iconography, transl. by Peter Chamberas and originally published in the Theological Review of Holy Cross School of Theology (1967-8). The mosaic in the quarter-sphere of the Bema of the Mone Latomou in Thessaloniki. The mosaic of Lord's Glory (5th century) displays Christ in the same manner placed within a round glory and sitting on a rainbow. Kalokyres, He Zografike tes Orthodoxias: 45. Christ is found in a representation on the drum above the entrance of the mausoleum of Galla Placidia leaning with royal ease onto the Cross, the symbol of his victory, young, beardless, with Apollonian beauty with all the grace and elegance inspired by the Hellenistic tradition. Ibid.: 48-9. Similarly in the quarter-dome of the St. Vitale apse Christ is represented in Paradise as beardless, "shining youth," sitting on the globe of the world surrounded by two angels. Below, in both sides of the arch the earthly kingdom is represented with Justinian on the north side and Theodora on the south side among court personages. Ibid.: 52

111 The dome of the cross-shaped mausoleum of Galla Placidia is decorated with a mosaic of a great cross placed on a deep blue sky, dotted with golden stars. Ibid.: 48-9. In St. Vitale in Ravenna on the top of the vault of the Bema the Savior as lamb is depicted within the round star-dotted glory supported by four angels, whose bodies create a cross. Ibid.: 52.

112 See Basilica of St. Apollinaire

113 To these properties correspond the various inscriptions that are placed around him. The inscription "Behold, behold that I am . . ." refers to the Creator. The inscription "Oversee from Heaven . . ." refers to the Savior, while the "this is God and judge of all . . ." to the Judge. Ibid.: 125-6.

114 Ibid.: 117.

115 Ibid.: 127.

116 John 10, 9 "I am the gate; whoever enters through me will be saved."

117 Matthew 23, 8.

118 John, 12, 35 and 46. This inscription is found in the representation of Christ as Gate in the central lunette of the narthex of Hagia Sophia (9th century). Thomas Whittemore, The Mosaics of Hagia Sophia at Istanbul (London: Oxford University Press for the Byzantine Institute, 1933) v.1: 16

119 Also, Grabar (Skira), La Peinture Byzantine, (Geneve, 1953):97.

120 Kalokyres, He Zografike tes Orthodoxias: 121-2.

121 Ibid.: 122-3.

122 Ibid.: 117.

123 Ibid.: 65-7.

124 Kalokyres, He Zografike tes Orthodoxias: 123.

125 Clement of Alexandria, "Stromateis", Patrologia Graeca 8: 11

126 "The speech of the Cross" of Apostle Paul to A' Corinthians 1,18.

127 John of Damascus, Athanasios the Great

128 Patrologia Graeca 11, 253, 4th Homily in the 1st Epistle to Timotheos.

129 Kalokyres, He Zografike tes Orthodoxias: 119.

130 In the verdant Paradise, the men wearing white clothes the women golden, deprived of weight, with their glances turned toward infinity, completely dematerialized, come in rhythmic procession to lay the wreaths of their martyrdom, the men before Christ and the women before Theotokos.

131 The strong features and the whole modeling of the faces declare that these live in the present world

132 Kalokyres, He Zografike tes Orthodoxias: 133.

133 Ibid.: 134.

134 See the hymn of the Resurrection "Come and receive light of the ever shining Light . . ." Also the Gospel of Easter stresses, that Christ "is the true light, which enlightens everyone who comes in this world," John 1, 9. Also see "Your Resurrection, Christ Savior, enlightened the entire universe . . ." John 16, 22.

135 Kalokyres, He Zografike tes Orthodoxias: 127-8.

136 Ibid.: 146.

137 Whitttemore, The Mosaics of Hagia Sophia at Istanbul: 23.

CHAPTER II

THE LITURGY AND THE MEANING OF LIGHT IN IT

The description that follows of the main part of the liturgy serves to establish the central role of light in the celebration of the liturgy. In the process, it provides a canonical framework for the analysis of certain phenomena that will follow, including an interpretation of some basic points that relate expressly to the conceptual, symbolic, or visual role of light. Interpretations of the liturgy have been produced by Cyril of Alexandria, Dionysius the Pseudo-Aeropagite, Maximus the Confessor, Anastasius of Sina, and Nicholas Cabasilas; the interpretation by Cabasilas (c. 1320-), ¹ considered to be superior has been employed here. ² Special emphasis is placed in elucidating the concept of “Liturgical Time” as well as determining the time of day in which the Eucharist was celebrated, as these aspects are crucial to the thesis of this study.

The Celebration of the Eucharist and its Interpretation

It is generally accepted that the Byzantine church was conceived primarily to accommodate the celebration of the Eucharist, which is the central service or “mystery” performed in the liturgy. ³ The purpose of the Eucharist service was to give everyone the opportunity to be cleansed, have their sins forgiven, and become enlightened. This was to be achieved through the consumption of bread and wine that had been sanctified and transformed into Christ’s flesh and blood.

The liturgy began with a formal entry into the church. ⁴ A prayer was said before the central door of the narthex, and was accompanied by a psalm. The entrance procession was led by the principal celebrant (at an important service by the patriarch) preceded by a deacon carrying the Gospel, seen as representing Christ. The other clergy followed.

On major feast days the whole congregation participated in the procession with the clergy from another church, probably entering through all the side doors from the

narthex as the clergy (and the emperor and his court, if they were present) entered through the central door. On other occasions, the congregation usually awaited the clerical procession in the atrium and narthex, probably being marshaled thereto provide for a seemly entrance. Sometimes, however, they awaited the procession inside the church, being led in their singing by some of the clergy. The procession of the clergy passed down the center of the nave and then, on reaching the ambo, proceeded down the solea, eventually entering the sanctuary. The Gospel was placed on the altar and the patriarch or other principal celebrant ascended to his throne on the synthronon and flanked down by the other clergy, greeted the assembled congregation.⁵

The liturgy opened with an elaborate blessing pronounced by the celebrant, 'Blessed be the Kingdom of the Father and of the Son and of the Holy Spirit, now and for ever and from all ages to all ages.' . . . The celebrant and the deacon then entered the sanctuary, took the Gospel book from the altar and carried it through the church and again into the sanctuary. There followed hymns for the day and then the appointed lessons for the day, first from the Acts or Epistles, then from the Gospels. Between the reading of the Epistle and the Gospel the priest said a prayer for knowledge . . .

O Merciful Master, cause the pure light of the knowledge of thee to shine in our hearts, and open the eyes of our mind to perceive thy message of Good Tidings; fill us with the fear of thy blessed commandments, that we, trampling down our fleshly desires, may seek a heavenly citizenship, and may do and consider all those things that are well pleasing to thee. For thou, Christ our God, art the source of light to our souls and bodies, and to thee we ascribe glory, with thine eternal Father and thine all-holy, righteous and life-giving Spirit, now and for ever and from all ages to all ages.

6

This was followed by three readings, all from the ambo, by appointed lectors and a deacon. A reading from the Old Testament has followed by a reading from the Epistle, and then the Gospel. The first two were not accompanied by any special ceremony, but for the third, the Gospel was ceremonially carried down the solea from the altar by the deacon and afterward returned to the altar by the route. The entry of the Gospel and its ensuing-reading were normally the climax of the first part of the liturgy service. If a

sermon followed, it was expected to expound upon the readings. Tradition held that the sermon should be delivered by the bishop or patriarch seated in his throne, while the congregation stood, as usual. Next, prayers were offered on behalf of the catechumens, who themselves they dismissed after prayer. At that point, the “eileton” was unfolded and prayers were offered on behalf of the faithful. ⁷

At the conclusion of the readings and the sermon, the principal celebrant and other clergy descended from the synthronon and moved to the altar for the second part of the service - the celebration of the Eucharist proper. This celebration began with prayers at the altar for bishops, priests, monks, and for the imperial family; ⁸ and there was a litany for the departed while the altar was made ready to receive the gifts. In the meantime, some of the deacons left to fetch the gifts from the skeuophylakion-the equivalent of the prothesis chapel or sacristy-and returned with them to the altar. At least from shortly after Justinian’s time, this procession, called *proskomide* or the great entrance, had acquired enough solemnity to be greeted by the people with a special chant - the Cherubic Hymn - when it re-entered the church:

We, who mystically represent the Cherubim and sing the thrice-holy hymn to the life-giving Trinity, let us lay aside all worldly care to receive the King of All, escorted unseen by the angelic hosts. Alleluia. ⁹

The celebrant now moved to a position just inside the sanctuary doors, where he asked for the prayers of the other clergy. He returned to the altar for the preparatory prayer known as the *proskomide*. After this, he gave the greeting of the Peace. The kiss of Peace was then exchanged by all in the church.

For the following central rite of the consecration of the gifts the celebrant and the deacon entered the sanctuary, took the paten and the chalice containing the elements from the altar, and went round the nave of the church, preceded by acolytes bearing lighted tapers. They recited prayers as they went. This was the Great Entrance. Bearing the elements, the ministers entered the sanctuary again and placed the chalice and paten on the altar. Another litany of supplication was recited by the deacon and the choir, and the

celebrant pronounced the Offertory Prayer:

O Lord God Almighty, who only art holy, who dost accept the sacrifice of praise from such as call upon thee with their whole heart, accept and receive also unto thy holy altar the prayer of us sinners, enabling us to present unto thee both gifts and spiritual sacrifices for our own sins and for the ignorances of the people: and count us worthy to find such favor before thee, that both our sacrifice may be acceptable unto thee, and the good Spirit of thy grace may rest upon us, and upon these gifts set forth, and upon all thy people. ¹⁰

A deacon, or perhaps a priest, dismissed, after a prayer on their behalf, the catechumens and the rest who were unworthy of the sacred sight of the mysteries, and the doors were closed. ¹¹ Ministers and people then joined in reciting the Creed; one of its essential provisions was the profession of belief:

I believe in one God, Father, Ruler of all both visible and invisible. And in one Lord, Jesus Christ, the only Son born to God by the Father before all eons; Light by Light, true God by true God, born not created, of the same essence as God, by whom all was created ¹² . . .

The offertory began. The Deacon went into the sanctuary and reverently began to fan the elements, using a metal fan of silver or gold, mounted on a long wooden staff, engraved to represent the six wings of the Seraphim. The celebrant then recited the prayer of thanksgiving and praise which was a confession of the goodness of God and his benefactions to men.

With this, the service began to draw near its climax. The celebrant proceeded to describe the Last Supper, and at the breaking of the bread, he recited the words of Christ, 'Take, eat; this is my body which is broken for you, for the remission of sins.' When he described how Christ took the cup, the priest again repeated the words, 'Drink ye all of this; this is my blood of the new covenant, which is shed for you and for many for the remission of sins.' Here the prayer enumerated all the actions of Christ which gave the communion its meaning;

Here we are commemorating the command of our Savior, and all that was endured for our sake, the Cross, the grave, the Resurrection after three days, the Ascension into Heaven, the enthronement at the right hand of the Father, and the second and glorious coming again - we bring before thee thine own, from thine own, in all things and for all things.

As these words were spoken, the deacon elevated the paten and the chalice, crossing his arms as he did so. At this point the celebrant began the long and beautiful prayer in which he called upon God to send down his Holy Spirit upon the people and their gifts, making the bread the precious Body of Christ, and making the cup his precious Blood, changing them, through the Holy Spirit, so that they might bring to those who receive them the means for the purification of the soul, the remission of sins, the fellowship of the Holy Spirit, and the fulfillment of the Kingdom of Heaven. ¹³

The long prayer continued, the deacon added the prayer that the Lord be mindful 'of those whom each of us hath in mind, and of all of men and women.' After prayers of thanksgiving and another litany, the celebrant again invoked the mystical presence of Christ:

Come and sanctify us, thou who sittest above with the Father and art here invisibly present with us, and do thou deign by thy mighty power to give to us of thy sacred Body and of thy precious Blood.

The celebrant then partook of the elements himself and afterwards to all those of priestly rank and the altar-servers. This was done with the doors of the sanctuary closed. After the ministers had said a prayer of thanksgiving, the doors of the sanctuary were opened and the congregation came forward to receive the communion. ¹⁴ Before administering the elements, the priest said a further prayer as a final declaration and petition just before the bread and wine were distributed:

I believe, Lord, and I acknowledge that thou art of a truth the Christ, the Son of the Living God, which came into the world to save sinners, of whom I am chief. I believe also that this is indeed thy most pure body, and that this is indeed thy precious blood. Therefore, I pray thee, have mercy upon me, forgive me mine offenses, voluntary and involuntary, whether in word or deed, whether witting or unwitting: and count me worthy to partake without condemnation of thy most pure mysteries, unto remission of sins and unto everlasting life.

Each communicant, as he came forward, bowed and crossed his hands on his chest, while the priest, taking up the bread and wine together in a spoon, placed them in the mouth of the communicant. When all the congregation had received the communion,

the deacon, holding the paten over the chalice, recited the hymns of the Resurrection. ¹⁵

Then, the faithful sang:

We saw the true light, we received the heavenly Holy Spirit, we found true faith worshipping the indivisible Trinity, for it saved us. ¹⁶

After a litany of thanksgiving, the priest recited a prayer summarizing the nature of the whole service. The priest then blessed the people and went into the sanctuary, closed the doors, and said a final personal prayer of thanksgiving. With the singing of the Song of Symeon and other hymns and prayers, the service came to an end. ¹⁷ The clergy left in the same order as they had come in; the celebrant and other senior clergy proceeded back down the solea and out through the narthex, to the skeuophylakion. The people then also left, and the sacred vessels and any residue of the consecrated gifts was taken back to the skeuophylakion. ¹⁸

In setting up the celebration of the Eucharist the religious fathers had stated explicitly that the complex meanings to be communicated should not be conveyed solely by preaching but be accompanied by images, the singing of psalms, and vivid action so as to excite the interest of the congregation and help them become involved in the divine mystery. ¹⁹ As will be seen light was called upon, to play a prominent role in evoking powerful mental images by properly emphasizing specific moments during the liturgy and various occasions in the course of the year.

According to Cabasilas the transformation of the elements into the divine body and blood is the most essential act in the celebration of the holy mystery. As a preparation for and contribution to this act there are prayers, psalms, and readings from Holy Scripture.

The plain offerings of the bread and wine, in order to be transformed into the Holy Sacraments it is necessary that they be dedicated to and blessed by God. Cabasilas tells us that is the consecration of these elements that transforms them into the very body and blood of Christ. The ordering of the liturgy, says Cabasilas, is made to correspond to

the events in the presence of Christ on earth, that are theologically most important. The ceremonies, he says, which precede the act of sacrifice symbolize the events which occurred before the death of Christ: his coming on earth, his first appearance and his perfect manifestation. Those which follow the act of sacrifice recall “the promise of the Father” ²⁰, that is, the descent of the Holy Spirit at Pentecost upon the apostles, the conversion of the nations which they brought about, and their divine society. ²¹

Cabasilas maintains that the effect and the result of the sufferings and works and teaching of Christ, considered in relation to ourselves, is nothing other than the descent of the Holy Spirit upon the Church. The transformation of the offerings of bread and wine to Holy Sacraments is thought to occur as a result of the descent of the Holy Spirit upon them. The Holy Spirit is considered to be sent by God in return to the offerings and as a gift of enlightenment. ²² The Church received the Holy Spirit, he says, after the Lord’s ascension and now after the offerings have been accepted at the heavenly altar. God, who has accepted them, sends the Holy Spirit in return. ²³ This point of the liturgy represents that moment in time, for the Holy Spirit came down after all things pertaining to Christ had been accomplished. And now the descent of the Spirit comes about when the sacrifice has been offered and the holy offerings have reached their perfection; it will be completed in those who communicate worthily. ²⁴ Communion with the Holy Spirit signifies the grace which through the descent of the Holy Spirit came upon the apostles. It is called communion because it formed a bridge between God and men. ²⁵ God, says Cabasilas, requires that men should be fit to receive and to preserve His graces which He gives to them freely and He will not permit those who are not so disposed to be sanctified. ²⁶

Cabasilas speaks of two ways in which the grace is given to the holy offerings. First, is the grace bestowed upon the offerings the working of which cannot be invalidated by any human evil. Second, is the grace bestowed upon the individual man. This, he says, demands man’s co-operation, and, as a result, his negligence can impede it.

Grace will sanctify a man through the sacred offerings only if it finds him ready and fit for sanctification. ²⁷

By making this distinction Cabasilas also makes a spatial distinction. The sanctification of the holy offerings that takes place within the apse, which is considered to be an objective phenomenon, and that which happens within the individual can only be witnessed by this individual and God. Hence, if light were to be employed as a visual aid to the comprehension of this mystery, it would have to shine upon the Holy Sacraments. Too it is reasonable that this signifying play of Divine light should take place within the apse and should be made plainly visible to all.

It was necessary that these actions, which are capable of inspiring such feelings in people, should find a place in the ordering of the liturgy. It was necessary, not only that the faithful should think about, but also that to some extent they should “see” the utter poverty of Him who possesses all, the coming on earth of Him who dwells everywhere, His shame, His sufferings; that they should see how much He was hated and how much He loved; how He humbled himself; what torments He endured, what deeds He accomplished in order to prepare for the faithful this holy table. Thus in beholding the freshness of the work of salvation, amazed by the abundance of God’s mercy, the faithful are brought to venerate Him who had such compassion for them, who saved them at so great a price: to entrust their souls to Him, to dedicate their lives to Him, to enkindle in their hearts the flame of His love. Thus prepared, we can enter into contact with the fire of the solemn mysteries with confidence and trust. ²⁸

The visual factor acquires great importance in Cabasilas’ interpretation. The purpose of the ceremonies of the liturgy, he says, is to set before the faithful the divine plan, so that by looking upon it their souls may be sanctified, and thus they may be made fit to receive the sacred gifts. Just as the work of redemption, when it was first achieved, restored the world, so now, when it is ever before their eyes, it makes their souls better and more divine. ²⁹ Cabasilas emphasizes the importance of visual imagery for the comprehension of the liturgy:

In order to put themselves in this state of mind it is not enough once to have learned of those things which are Christ’s and to have retained the memory of them; they must at this moment behold and contemplate these things with the eyes of the mind, striving to banish all alien thoughts; that is, if they truly wish to acquire that fitness of soul which makes them worthy of sanctification. In vain do they bear in mind the reverence due to

the holy mysteries in order to be able to answer any question which they are asked about it; if at the time of the celebration they do not concentrate upon these things, if their minds are distracted, such knowledge is not of the slightest use to them.

This is why the above-mentioned symbolism was conceived. It does not confine itself to the indication of all this by words alone, but it places it before one's eyes in its entirety throughout the liturgy. The aim of setting all this before the faithful is to influence their souls; not merely to offer them a simple picture but to create in them a feeling; because an idea is more deeply impressed upon them if they can see it depicted. This goes on throughout the liturgy, in order that it may not be forgotten, and their thoughts be not distracted by anything else before it has led them to the holy table. Filled with these ideas, and with their memory fresh within them, they receive Communion. In this way adding sanctification to sanctification, that of the sacred rite to that of the meditations, "We are changed from glory to glory", ³⁰ that is to say, from the lesser to that which is greatest of all. ³¹

"Liturgical Time" and the Time for Celebrating the Eucharist

Time in orthodox Christian worship is not considered in the sense of the natural flux of events, that is, of the past, the present, and the future. Instead, the past and the future are considered simultaneously as the eternal present. This is called "liturgical" or "concentrated" time. ³² Time is thus transmuted into a mystical experience in which eternity and things belonging to the present, the past, and the future are mysteriously condensed, and, thus, are being experienced by the faithful. Therefore, the events of religious history are not understood as things that have simply happened in the past but as situations that are mystically taking place and actions that are being acted in the present. ³³ Church dogma has it that the worshipper receives communion of the Body and the Blood of Christ not in memory of Christ who had once been sacrificed, but by partaking of Christ, who is *being* sacrificed and is *being* offered to the faithful to consume *each time* the liturgy is celebrated. He is also thought to live presently the entire history of the Church. This conception of time has significant repercussions on orthodox iconography. The sacred persons and the events are depicted in such a way as to appear that they belong in an eternal present. This is usually, achieved, by the elimination of details that would remind one of a specific point in history. But it is sometimes effected also by the

depiction of contemporary events (to the time of the execution of the painting) within scenes that took place many hundreds of years earlier.³⁴

Another characteristic conception is that, within the church, time is sanctified. No longer is time understood as a linear progression filled with a variety of life functions and events. Time retains its cyclical character but its progression is eliminated. Each hour is ascribed a sacred significance. The daily cycle has been transformed into a sacred cycle marked by the commemoration of significant religious events not in a historical but in a liturgical sequence.³⁵ The reading of the *Hours*, a significant part of the liturgy,³⁶ was associated with certain liturgical functions, and was initiated when the sun reached a certain position. These began with the *First Hour*, the opening service of the morning, with thanksgiving for the light of the new day. The *Third Hour* (which at present would be about nine o' clock), commemorated the descent of the Holy Spirit at Pentecost. The *Sixth Hour* (noon), commemorated the crucifixion of Christ and the *Ninth Hour* (three in the afternoon), commemorated the death of Christ. The ordinary person was not usually able to take part in all these services, but they were celebrated daily by the priests and deacons in the churches, and by the monks and nuns in their communities.³⁷ The correspondence of the Byzantine hour designations to present day hours, indicated above, is approximate and would only be precise twice a year, on the days of the equinox.³⁸

Of particular interest to this study is the connection between the third hour and the Pentecost (a movable feast celebrated fifty days after Easter Sunday). The descent of the Holy Spirit, which is believed to have occurred on that day, is conceived as an outpouring of light or fire upon the Church.³⁹ The day of the Pentecost is considered to be the day of the establishment of the Church as an institution. The scriptures state that the descent of the Holy Spirit on that day caused the transformation of the apostles into illumined beings and enabled them to teach Christianity to the world in many different languages even though they were illiterate fishermen. The Holy Communion of the Eucharist celebrated in the liturgy has an equivalent transformation as its principal aim. Thus, there is an

intimate liturgical bond between the two. Regarding the time of the occurrence of the Pentecostal miracle, it is stated in the scriptures that the Holy Spirit descended on the third hour.⁴⁰ For this reason, this event is commemorated on the third hour of every day.

It is also important at this point to determine the approximate length of this service. The celebration of the Divine Liturgy consisted of the service of Holy Communion. The preparation for participation in the liturgy began the day before, with the confession and absolution of each person who desired to receive communion.⁴¹ In the early morning, Matins (OrqroV) were celebrated, and after this, without a break, the Divine Liturgy began with the preliminary service of the vesting of the clergy and the preparation of the bread and wine.⁴² In the Constantinople of Justinian's time the text of the liturgy in common use was ascribed to St. John Chrysostom of Antioch, the "Golden Tongued," who ended his career as Patriarch of Constantinople. This service was unhurried and never abbreviated: together with the Matins, it would take three hours, sometimes more.⁴³ Today, on Mount Athos, there is a short break between the celebration of the Matins and the service. In Justinian's era, similar breaks must have been used as time regulators, becoming longer or shorter according to the season; the priest must have consulted some kind of time keeping device for their exact duration. There is reference to a small building called the Horologion (Clock - now lost) in Hagia Sophia of Istanbul which was often consulted by the priest.⁴⁴

The calendar was filled, on both Sundays and week days, with various special services which constituted the Christian year. At each of these, the liturgy was celebrated, along with the particular service provided for the occasion. A list of the great festivals and some of lesser or local importance is appended to this study. (see Appendix 2)

Notes to Chapter II

¹ Saint Nicolaos Cabasilas, Erminia tis Theias Leitourgias [Interpretation of the Divine Liturgy], (Thessaloniki: Perivoli tes Panagias, 1991): 15 Cabasilas was a devoted adherent of the emperor John VI Cantacouzenous and a relative of the appointed archbishop of Thessalonica Nilus Cabasilas (1361). Gregory Palamas was the immediate predecessor of Nilus Cabasilas in the archiepiscopal see of Thessalonica. Nicholas Cabasilas lived in times not only of political strife but also of theological controversy. Besides the perennial dispute with Rome the Orthodox Church itself was profoundly disturbed and divided by the question of "Palamism". To the Orthodox, the Christian *par excellence* was the monk, and among the monks the most revered were the "hesychasts" who lived alone, each in his own retreat, practising incredible austerities and spending his time in prayer and the stillness (hesychia) of contemplation. In the fourteenth century these solitaries of Mount Athos held that the climax of hesychast contemplation was the vision of the divine light, which was nothing less than the pure divine energy, the uncreated Light which shone on Mount Tabor in the Transfiguration of Christ. This doctrine was assailed as blasphemous by a Calabrian monk named Barlaam. But it found an able defender in the celebrated Gregory Palamas, who worked out a theological theory for it, and it was finally accepted officially at the Council of St.Sophia (1351). The Emperor John Cantacouzenus supported Palamas and the Athonite monks, and presided at the council of St Sophia. And it was here that the sympathies of Nicholas Cabasilas lay. Nicholas Cabasilas was one of the two ambassadors sent by the city of Thessalonica to Manuel Cantacouzenus at Beroea in 1346. In 1354 he was proposed among three candidates for the Patriarchal see but was not chosen by the Emperor Matthew Cantacouzenus. Nicholas Cabasilas, A Commentary on the Divine Liturgy transl. J.M.Hussey & P.A. McNulty (London:S.P.C.K., 1960): viii-xi. He wrote several theological works among which the most important are "The Life in Christ" and the "Commentary on the Divine Liturgy" and he is held in high esteem both in the Eastern and Western church. The original text that is used can be found in Patrologia Graeca v.150: 368-492.

² Saint Cabasilas, Erminia tes Theias Leitourgias: 17.

³ See Mango Byzantium:The Empire of New Rome, (London: Weidenfeld & Nicolson, 1980). Also Krautheimer Early Christian and Byzantine Architecture, (Maryland: Penguin Books, 1965).

⁴ Mathews, Early Churches: 38-9; also J. Mateos, "Celebration de la Parole dans la Liturgie Byzantine," Orientalia Christiana Analecta (Rome, 1971): 191.

⁵ Mainstone, Hagia Sophia: 227.

⁶ Downey, Constantinople: 124-5.

⁷ Ioannis B. Kogoulis He Theia Leitourgia tou Agiou Ioannou tou Hrisostomou [The Divine Liturgy of Saint John the Chrisostom] (Thessaloniki: Lidia, 1991): 71-5.

⁸ Downey, Constantinople: 125.

⁹ Cedrenus, Patrologia Graeca, 121: 748. For the entrance generally see Robert Taft, "The Great Entrance" Orientalia Christiana Analecta (Rome, 1975): 200, 1978.

¹⁰ Also see Kogoulis He Theia Leitourgia tou Agiou Ioannou tou Hrisostomo (Thessaloniki Lidia, 1991):87.

¹¹ Maximos o Omologetes, Mystagogia transl. I. Sakales (Athens: Apostolike Diakonia tes Ekklesias tes Ellados, 1989): 14, 15, Patrologia Graeca, 91: 692-3; Also see Mainstone, Hagia Sophia: 227-8.

¹² Kogoulis He Theia Leitourgia tou Agiou Ioannou tou Hrisostomou (Thessaloniki Lidia, 1991):88-9. Also see Goodenough, Erwin R., By Light, Light: The Mystic Gospel of Hellenistic Judaism (Amsterdam: Philo Press, 1969).

¹³ Downey, Constantinople: 125-7.

¹⁴ Mainstone, Hagia Sophia: 228.

¹⁵ Downey, Constantinople: 130.

¹⁶ Kogoulis He Theia Leitourgia tou Agiou Ioannou tou Hrisostomou (Thessaloniki Lidia, 1991): 117.

¹⁷ Downey, Constantinople: 131.

¹⁸ Mainstone, Hagia Sophia: 228.

¹⁹ See multiple references on this matter in Maximus the Confessor Mystagogia, [Mystagogy].

²⁰ Luke 24, 49; Acts of the Apostles 1, 4.

²¹ Cabasilas, A Commentary on the Divine Liturgy: 26-7.

²² A number of references from various church fathers is presented in Chapter 1 of this dissertation.

²³ Cabasilas, A Commentary on the Divine Liturgy: 90-1.

²⁴ Ibid.: 90.

²⁵ 2 Peter 1,4 cited in Cabasilas, A Commentary on the Divine Liturgy: 49-50.

²⁶ Cabasilas, A Commentary on the Divine Liturgy: 25.

²⁷ Ibid.: 85-6.

²⁸ Ibid.: 85

²⁹ Ibid.: 86

³⁰ Corinthians, 3,18

³¹ Cabasilas, A Commentary on the Divine Liturgy: 28-30.

³² George Pidoux, "A Propos de la Notion Biblique du Temps," Revue de Theologie et de Philosophie (Lausanne, 1952): 120ff; Also see Sava X. Agouridou, Hronos kai Aioniotis en ti Theologiki Didaskalia Ioannou tou Theologou [Time and Eternity in the Theological Teachings of John the Theologian] (Thessaloniki, 1959): 37.

³³ Konstantinos Kalokyris, "Byzantine Iconography and Liturgical Time," Eastern Churches Review 1 (1967-68): 359-363.

³⁴ Konstantinos Kalokyris, H Zografiki tis Orthodoxias: 208-9.

³⁵ Downey, Constantinople: 114.

³⁶ See the liturgical book Horologion [Clock]

³⁷ Downey, Constantinople: 114.

³⁸ See chapter 3 for more details.

³⁹ Thomas J. Talley, Encyclopedia of Religion (1987) 15: 453. Also see Acts of the Apostles 2, 1-15.

⁴⁰ Ibid.

⁴¹ , Constantinople: 122.

⁴² Ibid.: 122-3.

⁴³ Ibid.: 118. Also see Kogoulis He Theia Leitourgia tou Agiou Ioannou tou Hrisostomou (Thessaloniki Lidia, 1991).

⁴⁴ See chapter 5.

CHAPTER III

THE BYZANTINE CALENDAR AND METHOD OF TIME MEASUREMENT

The purpose of this chapter is to discuss, on the basis of existing scholarship, the calendaric variables the Byzantine architect ought to take into account if he were to design according to the way suggested in this study. The type of calendar used, the division of day, the length of night and day, and the designation and length of the hours were all determined in a different manner than they are today. Their clarification is therefore critical to the subject of this study, which is inseparably connected to the motion of the heavenly bodies in the sky. This would allow one to fully comprehend the specific calculations involved in designing the lighting conditions within the church in ways that would psychologically enhance religious experience.

The first to be examined is the way in which time was measured within a single day. This is necessary because the method used in Byzantine times was not only quite different from the one in use today, but, more significantly, because the Byzantine method was more closely related to the motion of the sun and, consequently, to the fluctuation of this motion in the course of a year. Also included is, a discussion of the time keeping instruments of that era - - such as sundials, water clocks, or other devices - - together with an analysis of the Julian calendar, which was in use during Byzantine times. The later's importance cannot be overstressed, inasmuch as certain effects whose conception and design would have been based on the Julian calendar may not be apparent today - - during the days of the year for which they were intended - - because of the cumulative error of the Julian calendar.

The Division of Day

The first point to be examined is the time of day when the measurement of the day commenced. There were considerable differences among the various civilizations in

respect to this point but differences could also be observed within a single culture depending upon whether the day was viewed from a juridical, ecclesiastical, civil, or astronomical point of view.

The Hebrews and the ancient Greeks commenced the day at night. The Chaldeans, the Egyptians, the Syrians, and the Romans commenced the day in the morning; the latter, however, commenced it at midnight when sacred functions or juridical affairs were concerned. The middle of the day was the point of departure chosen for the Ptolemaic astronomical calculations and which was followed by the majority of astronomers. For the Byzantines, as a general rule, the day commenced in the morning wherever the Julian calendar was introduced.¹ These variations in the designation of the beginning of a new day resulted in a considerable variation in the calculation of the date of Easter between the Eastern and the Western church, as we shall see later.

In Byzantine times, the natural day, or *luminous*, was divided into 12 equal parts, and the same division was applied to the night. So there were 12 hours per day and 12 hours per night, making for 24 hours in all, or what was called the *nychtemeron*, which stands for the whole of day and night. The measurement of time depended on the daily motion of the sun in the sky. As a result, the day and the night varied in length according to the seasons. The hours followed these variations so that the diurnal hours were taken as being longer in summer, and shorter in winter, and the nocturnal hours as longer in winter and shorter in summer. These unequal hours were called *kairikai* or *temporales* or *inaequales*; and hereafter, they will be referred to as “seasonal.” The diurnal and nocturnal hours were equal in length only in the days of equinox which occurred twice a year (March and September). Because of their equal length these hours were called *isemerinai* or *aequinoxiales* and hereafter they will be referred to as “equinoctial.”

The Romans divided the solar day of 12 seasonal hours in four great sections: *mane*, *ad meridiem*, *de meridie*, *suprema*; and the night in four watches (*vigiliae*). This division was also followed by the Hebrews, at the time of Christ, and was observed by

the Christians as well, who applied it to the distribution of public prayers. The prayers thus assumed the name of the hour in which they occurred. Initially, there were the third, sixth, ninth and twelfth hours. But, from the 5th century onward, an hour was added at the commencement and one at the end of the day. The correspondence with the solar day was the following:

Hora prima, ora prote, first hour, at sunrise,
 Hora tertia, ora trite, third hour, middle of the morning,
 Hora sexta, ora ekte, sixth hour, noon,
 Hora nona, ora enate, ninth hour, middle of the afternoon,
 Vespera, esperinon, 1 (seasonal) hour before sunset,
 Completorium, apodeipnon, at sunset. ²

In the West the following divisions of the night are found: 1. *Caput vigiliarum* or *conticinium*; 2. *Vigilia media* or *intempestum*; 3. *Gallicinium* or *gallicantus*; 4. *Matutinum*. The analogous designations did not exist in the East, except for the *matutinum* which corresponds to *orthros*.

The subdivisions of the seasonal hours in common usage in the West were ordinarily the half-hour and the quarter-hour. But computists, chronologers and ecclesiastic writers presented a greater hierarchy of measures. The most frequent division is the following:

1 hora =	4 puncta =	40 momenta =	480 unciae =	21600 atomi
	1 punctum =	10 momenta =	120 unciae =	5400 atomi
		1 momentum =	12 unciae =	540 atomi
			1 uncia =	45 atomi

The analogous information is not found in the Byzantines for the seasonal hours, but only for the equinoctial hours. The division of the *nychthemeron* in equinoctial hours, provided for the need of the astronomers for the establishment in their calculations, of a common measure for all days of the year.

The Chaldeans divided the *nychthemeron* in 12 equal parts that were called *kas-pu* or *kas-bu* (double hour). This subdivision was preferred because the number 12, as opposed to 24, is an under multiple of 60, which represented the basis and center of the Chaldean system of calculation. Every double hour was divided in 30 *us*, the value of which was equivalent to four of our minutes. The day had therefore 360*us*, as many as the degrees of the circumference.

The Babylonian astronomers, for the convenience of calculation, divided the *nychthemeron* in 6 parts, 60 degrees each, one degree having the value of 60 minutes, one minute of 60 seconds. This division of the day in 6 parts, which served in the computation of the lunar cycle, is found again among the Byzantine computists. But the Babylonian astronomers used a division of the *nychthemeron* in 12 equal parts as well which was also practiced by some Christian computists, like Saint Epiphanius and Dionysius the Little. These parts, which they were also called hours, were again equivalent to two of our own hours. Other computists employed the division in 24 equal hours, like Bedes in the West, and Psellos and the Anonymous A of Karthaler in the East. But the latter two differed concerning the subdivisions of the hour.³

Psellos	Anonymous A of Karthaler
1 hour = 5 lepta	1 hour = 5 stigmai
1 lepton = 4 stigmai	1 stigmi = 2 lepta
1 stigmi = 12 ropai	1 lepton = 15 moirai
	1 moira = 8 ripai
	1 ripi = 12 endeixeis
	1 endeixis = 60 atoma

The frequent occurrence of Byzantine church domes with six, twelve, or twenty-four windows probably reflect the various subdivisions of the day discussed above. The dome was thought as a representation of heaven. Considering this in connection to the fact that the earth, by church dogma and contrary to contemporary scientific knowledge,

was considered to be flat ⁴ and that the sun hid behind faraway mountains during the night, ⁵ a fenestration design accounting for the motion at least of the major heavenly bodies would appear natural.

The liturgical importance of the third hour was established in the previous chapter. In order to determine, now, the midmorning position of the sun for a given day the seasonal *third hour* - - which would fluctuate from about 8 a.m. to 10 a.m. depending on the season - - would have to be calculated. The calculation of the position of the sun on each seasonal hour in those days could be effected in two ways. First, by using a water clock or anaphoric clock described by Vitruvius,⁶ which would ascribe equal length of time to each seasonal hour, and second, by subdividing the course of the sun in the sky into twelve equal parts ⁷ and assigning them a value in degrees with the aid of the "Handy Tables." ⁸ (the angle varied for each day and depended on the latitude of each location). Since the motion of the sun in the sky does not have a constant speed the two methods do not provide the same results.

Today, on Mount Athos the day begins at sunrise or sunset. The counting of the hours is usually conducted by setting the sunset as 12 midnight. Even though the clocks are adjusted in order to account for the different seasons and approximate the seasonal hours, the use of modern "equinoctial" clocks precludes the subtle relationship of time to the sun motion that was only possible with the ancient sundials and waterclocks.

Time keeping Instruments

Sundials and water clocks were in common use throughout the Greek, Roman, and Byzantine periods. This is supported by numerous archaeological findings as well as detailed literary descriptions of similar instruments. Vitruvius (1st century B.C.) ⁹ describes the geometry of the "analemma," a method of finding, by means of geometric constructions in the plane, certain arcs and angles which determine a point on the celestial sphere. The main field of application of the analemma is the theory of sundials. ¹⁰

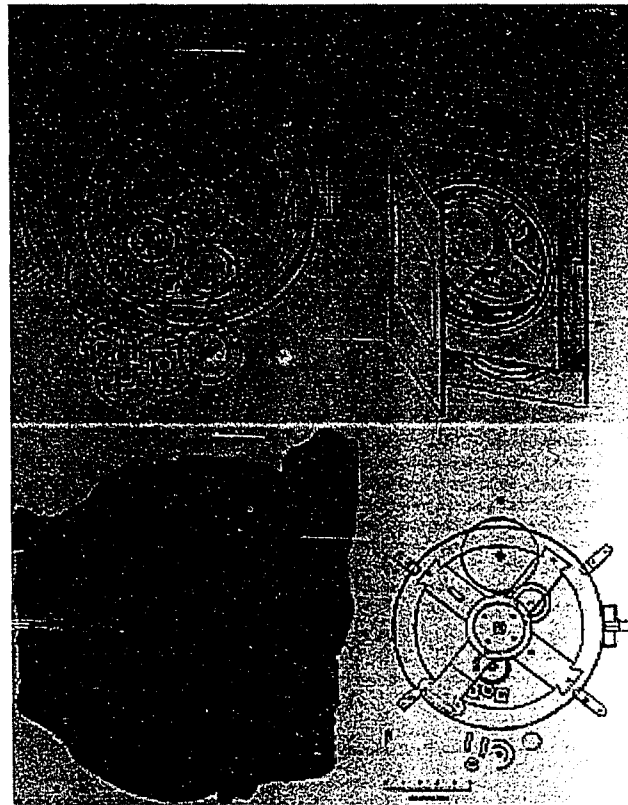


Fig. 3.1 Astronomical Instrument found in Antikythera 80 B.C.

Ptolemy, the astronomer, (2nd c. A.D.), also describes the “analemma” along with various astronomical devices.¹¹ Vitruvius refers to a number of inventors and their sundials by name. He also describes water clocks in great detail. Sundials and water clocks had been in common use as late as the 18th century,¹² and they probably constituted the principal means of time keeping during Byzantine times.¹³

However, these were not the only means of time keeping known in antiquity. A very complex astronomical instrument showing the motions of the sun, the moon, and the earth, probably constructed in the island of Rhodes (c. 80 B.C.) was found in the island of Antikythera (Fig. 3.1).¹⁴ Another recently discovered mechanical calendar from Byzantine times, (5th or 6th century) is a kind of portable sundial with a mechanical calendar incorporated into it (Fig. 3.2). It was able to indicate lunar time, the positions of the sun

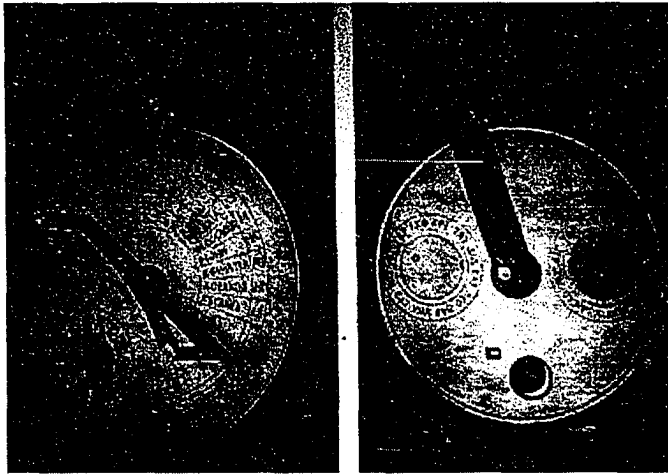


Fig. 3.2 Byzantine solar sundial and mechanical calendar

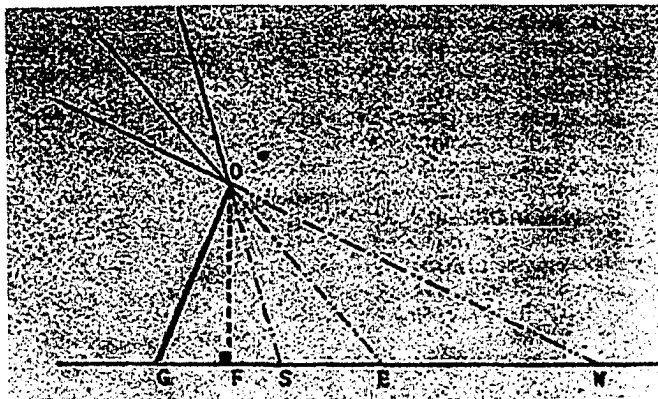


Fig. 3.3 Sundial with gnomon, section

and the moon in the zodiacal circle and the relationship of these to the day of the week. This instrument was similar to the Antikythera mechanism but of inferior construction.¹⁵ Therefore, the claim of Swift that mechanical clocks may have been in use at the time of Justinian and particularly for the timing of the liturgy appears probable.¹⁶

Sundials, however, were the principal means by which the hours of the day were defined, and the water clock, or anaphoric clock, was responsible for the more refined time keeping (such as the timing of public orators), showing the precise subdivision of seasonal hours of day or night for any day of the year.¹⁷ A simple sundial consisted of a metal rod, called “gnomon”, attached onto a flat or hollow spherical surface with hour markings (Figure 3.3). The time of day was indicated by the position of the gnomon’s

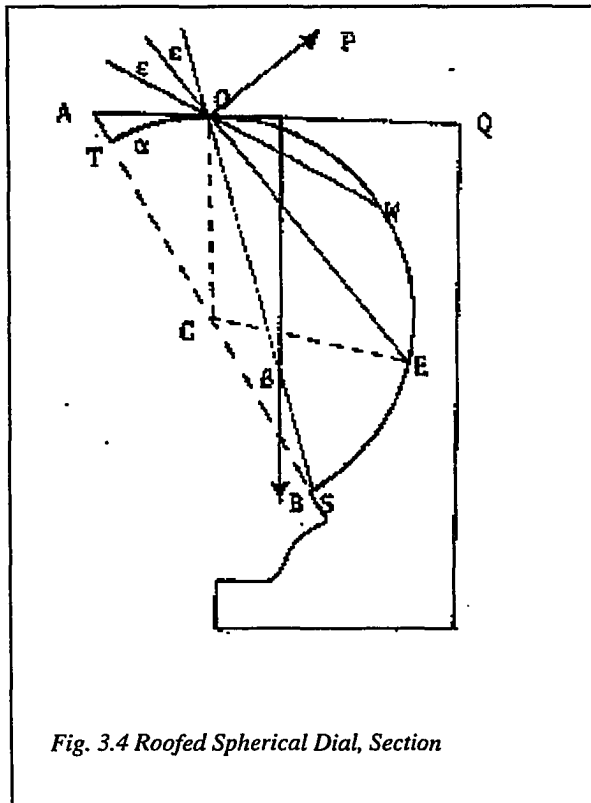


Fig. 3.4 Roofed Spherical Dial, Section

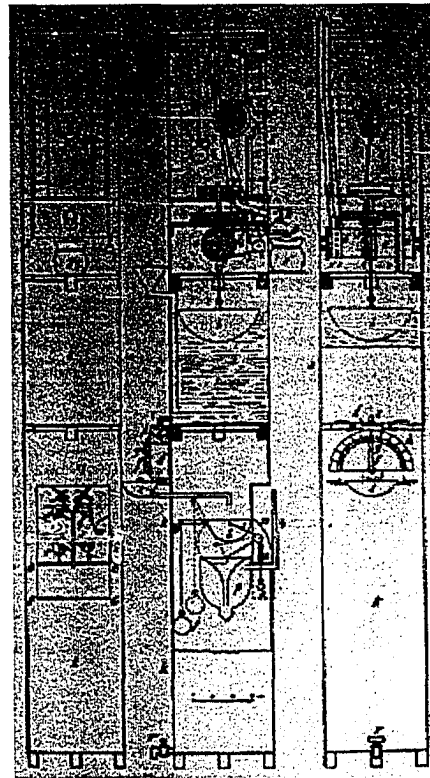


Fig. 3.5 Archimedes' waterclock

shadow in relation to the surface markings. A "roofed spherical dial" is a similar device which allows sunrays to enter through a hole on the upper level of a semi-enclosed, concave space (Figure 3.4). The time in this case was indicated by the position of a spot of sunlight on the shaded surfaces enclosing this space.¹⁸

Archimedes (3rd c. B.C.) invented a water clock capable of telling both diurnal and nocturnal seasonal hours (Fig. 3.5).¹⁹ Ctesibius (3rd c. B.C.) was the inventor of the constant-flow water clock, as well as of the parastatic and the zodiac-regulated clock. The last two were able to indicate the seasonal hours as they varied from day to day (Figs. 3.6, 3.7).²⁰ Apollonius of Perga constructed the first concave sundial (Fig. 3.8).²¹

Andronicus Kyrrestes (1st c. B.C.) designed the water clock of the Tower of Winds in Athens, a combination of weather vane, sundial, and water-clock (Fig. 3.9).²² The architect Parmenion invented a type of sundial like the one found in Philippoi (300

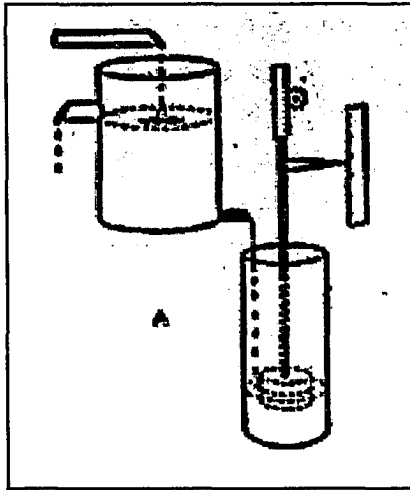


Fig. 3.6 Ctesibius' constant flow waterclock

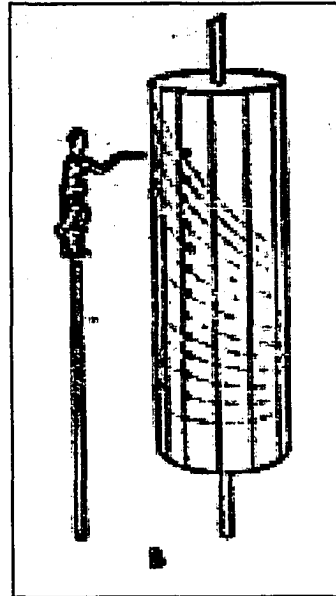


Fig. 3.7 Ctesibius parastatic clock

A.D.), which was portable, as opposed to those that were location specific (Fig. 3.10).²³

What is of importance to this study is in fact that the 12 seasonal diurnal hours were considered to be of equal length in any one day of the year and this was true for the 12 nocturnal hours as well. The diurnal hours, however, were considered longer or shorter than the nocturnal depending on the season.²⁴ This point is important because it allows us to define the azimuth and the altitude of the sun for any of the diurnal seasonal hours in any given day of the year. In this way it is possible to determine the angle in which sunlight entered the church on the seasonal hours throughout the day and the year.

The Astronomical Calendar

In grasping the overall lighting concept employed in the Byzantine church, a basic difficulty facing the modern researcher stems from the fact that the Julian calendar, falling gradually out of pace by its accumulating error, has interfered with certain light

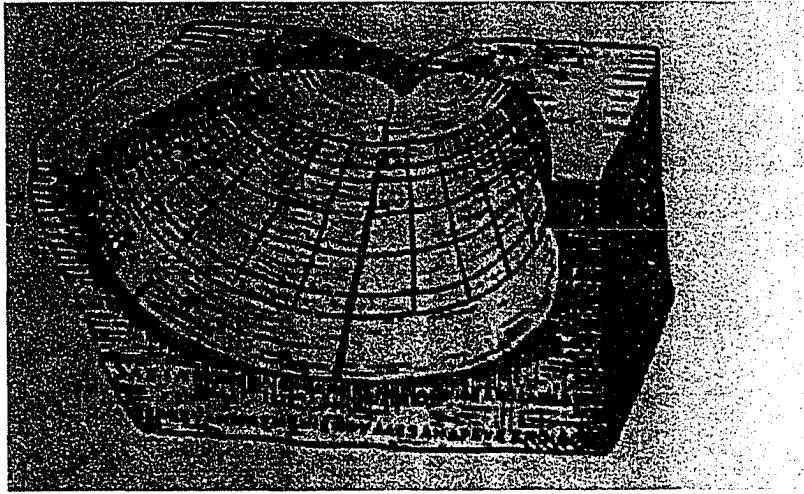
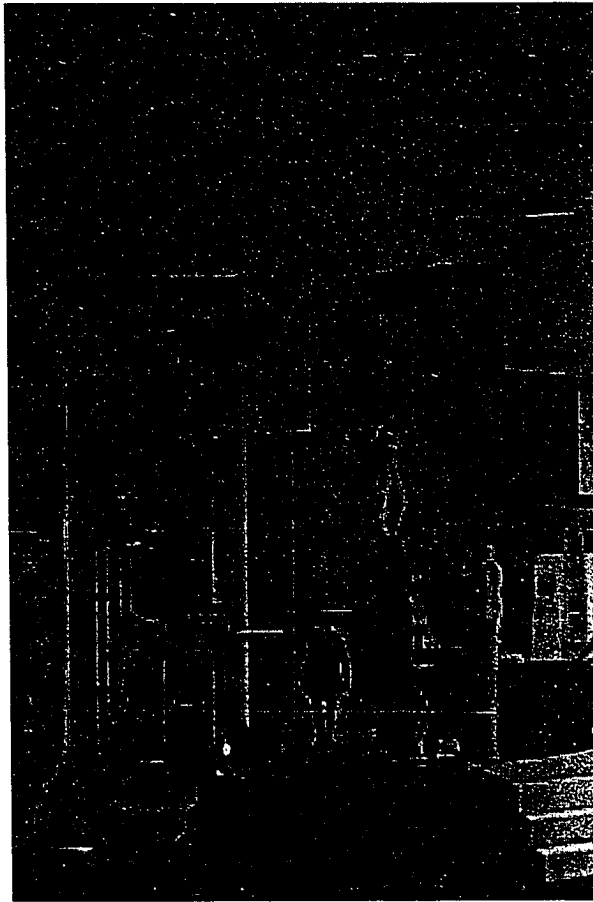


Fig. 3.8 Apollonius' of Perga. Concave sundial

effects that were meant to occur during certain liturgically significant days of the year. On Mount Athos, where the Julian calendar is still in use, the day of the year on which a feast is celebrated occurs considerably later than when the Julian calendar was initially implemented. In some cases this results in a significant alteration of sun angles. This fact would have made the light effect be perceived as a random occurrence, since it would not have coincided with a significant event in the liturgy.²⁵

The Byzantine calendar did not differ from the Roman. It adopted the Roman names of the months, the date of the commencement of the year in the 1st of September, and the designation of days into months. The Byzantine calendar coexisted in Syria and Egypt with the local calendars. After the loss of these regions in the 7th century, the Byzantine calendar was the only one employed in the entire Empire.

This Roman-Byzantine calendar was first implemented in 45 B.C. It was named Julian after the Roman Emperor Julius Caesar, who initiated it to reform the previous Roman calendar. The reform was carried out by the Alexandrine astronomer Sosigenes. The duration of the months was modified, one day was added to the month of February every four years, and the beginning of the civil year was moved to the first of January. ²⁶



*Fig. 3.9 Andronicus Kyrrestes' waterclock
of the Tower of Winds, Athens*

In most calendars the main objective is to reconcile the cycles of the sun and the moon. Sosigenes abandoned the lunar calendar altogether. Months were arranged on a seasonal basis, and a tropical (solar) year was used, as in the Egyptian calendar, but with its length taken as 365 $\frac{1}{4}$ days. A calendar year of 365 days was adopted and an extra day was intercalated between February 23 and 24 every fourth year. There were no weeks in the original Julian calendar, but days were designated either *dies fasti* or *dies nefasti*, the former being business days and days on which the courts were open. The seven-day week was introduced by the Byzantine Emperor Constantine I in the 4th century A.D.

Since 153 B.C., still the time in which the Roman republican calendar was in use,

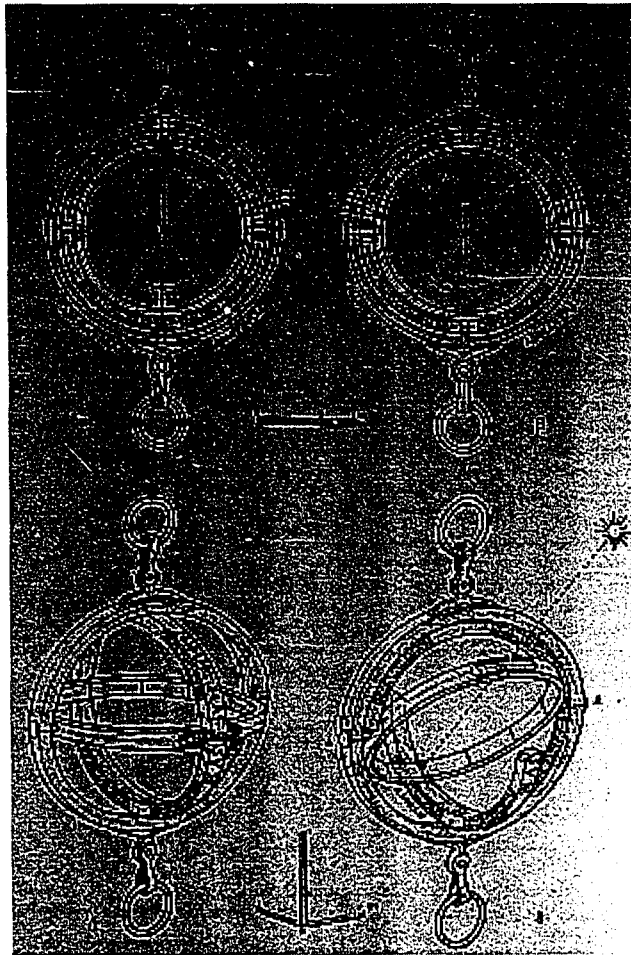


Fig. 3.10 Portable sundial of Philippoi

January became the first month of the year, and in the western region of the Roman Empire, this practice was carried over into the Julian calendar. In the eastern provinces, however, years were often reckoned from the accession of the reigning emperor.²⁷

The Julian calendar year of 365.25 days was too long, since the correct value for the tropical year is 365.242199 days. This error of 11 minutes 14 seconds per year amounted to almost one and a half days in two centuries, and seven days in 1,000 years. By 1545 the vernal equinox, which was used to determine Easter, had moved 10 days from its proper date. A papal bull issued in February 1582 sought to bring the vernal equinox back to March 21 and second, to bring the year closer to the true tropical year,

therefore accepting a value of 365.2422 days (Gregorian calendar). This value differed by 0.0078 days per year from the Julian calendar reckoning, amounting to 0.78 days per century, or 3.12 days every 400 years. It was therefore promulgated that three out of every four centennial years should be common years, that is, not leap years; and this led to the rule that no centennial years should be leap years unless exactly divisible by 400.

In order to account for this difference between the Julian and the Gregorian calendar a computer program was employed to determine of the position of the sun, which calculates apparent time using the Julian calendar. This program provides the exact position of the sun at any time of day that is specified, which, for the purposes of this study, is usually the first celebration of the feast day of the church , that is, after the completion of the building. ²⁸

Notes to Chapter III

¹ Victor Grumel, Traité d'Études Byzantines I: La Chronologie (Paris: P. Lemerle, Press Universitaires de France, 1958): 163-5.

² This subdivision is employed in Appendix 3 for the calculation of sun angles. Ibid.

³ Ibid.

⁴ Ptolemy, the astronomer (2nd c. A.D.), represented the terrestrial globe as a sphere rotating about its polar axis. Otto Neugebauer, A History of Ancient Mathematical Astronomy, v. 2: 889.

⁵ Cyril Mango, Byzantium: The Empire of New Rome (London: Weidenfeld & Nicolson, 1980): 42

⁶ For a description of an anaphoric clock see Vitruvius, De Architectura 9, 8. Such as those found in Salzburg and north-eastern France. See Neugebauer, A History of Ancient Mathematical Astronomy, v. 2: 870.

⁷ "One twelfth of this arc (the arc of a circle of constant declination between sunrise and sunset) gives the length of one seasonal hour." Ibid.: 843. And elsewhere again "The points which divide these arcs (the half day-arcs at the longest and shortest day) into 6 equal parts represent the positions of the sun at the end of each seasonal hour at the solstices." Ibid. v. 2: 844.

⁸ Ibid. v.2:980-1; 1033. See also Halma, Handy Tables.I:1-26; and Heiberg ed., Ptolemy, Opera II: 159-185. The "Handy Tables" were authored by Ptolemy in the 2nd century and their influence was felt during the whole Byzantine and Islamic period and reached the European West in the "Alfonsine Tables." The Handy Tables included precise information for the sun, moon, and planetary phases. Neugebauer, A History of Ancient Mathematical Astronomy, v. 2: 969-971.

⁹ Neugebauer places Vitruvius in the decades around the beginning of our era. Ibid. v. 2: 869.

¹⁰ Vitruvius De Architectura 9, 7. Also Neugebauer, A History of Ancient Mathematical Astronomy, v. 2: 839-845.

¹¹ Ibid. v. 2: 839.

¹² Sharon L. Gibbs, Greek and Roman Sundials (New Haven and London: Yale University Press, 1976): 3

¹³ G. Mendel, Catalogue des Sculptures Grecques, Romaines, et Byzantines, v. 2, :567. Also, see Byzantinische Zeitschrift 3 (1894): 16 and Syria 9 (1928): 80.

¹⁴ Derek de Solla Price, "Gears from the Greeks: The Antikythera Mechanism-A Calendar Computer," in Transactions of the American Philosophical

Society, New Series, v. 64, part 7, 1974.

¹⁵ Pierre Thuillier, "Les Mecaniciens Grecs Sortent de l' Ombre," La Recherche, no. 172 (Dec., 1985): 1540-1544. Also, J.V. Field and M.T. Wright, "Gears from the Byzantines: A Portable Sundial with Calendrical Gearing," Annals of Science, 42 (1985): 87-138.

¹⁶ See chapter 5

¹⁷ Vitruvius De Architectura 9, 8. Also, Neugebauer, A History of Ancient Mathematical Astronomy, v.2: 869-870.

¹⁸ Gibbs, Greek and Roman Sundials: 23.

¹⁹ Eleutherios Stamatis, Arhimidous Apanda [The Complete Works of Archimides] vol. C : 231-308 and 342-379. This clock was reconstructed by I. Saccas.

²⁰ A.G. Drachmann, Ktesibios, Philon and Heron. A study in Ancient Pneumatics (Copenhagen, 1948). Also, Bertrand Gille, Les Mecaniciens Grecs: la naissance de la Technologie, (Paris, 1980).

²¹ Gibbs, Greek and Roman Sundials: 25

²² Derek de Solla Price and J. Noble, "The Water-Clock in the tower of Winds", American Journal of Archaeology, 72, 4 (Oct. 1968): 345-355. Also see, Henry S. Robinson, "The Tower of Winds and the Roman Market-Place", American Journal of Archaeology, 47 (Oct. 1943): 291-305.

²³ Georgios Gounaris, "Halkino Forito Eiliako Orologio apo tous Filippous" [Portable Copper Sundial from Philippoi] Archaeologiki Efimeris [Antiquities Journal] (1978): 181-191.

²⁴ Vitruvius De Architectura 9, 8. Discussion of Clepsydras as clarified by Derek J. Price in "Precision Instruments: To 1500," in A History of Technology, C.J.Singer et al. eds., vol.3 (Oxford: Clarendon Press, 1957): 601-603. Also see Gibbs, Greek and Roman Sundials: 4. "Greek and Roman sundials always marked the twelve seasonal hours of daylight between sunrise and sunset. But while the seasonal hours were of equal length during a given day, their length varied during the year, being shortest at winter solstice, and longest at summer solstice."

²⁵ This perceived randomness is reflected in a study conducted by Yiannis D. Triantafyllides, Stoicheia Physikou Photismou ton Byzantinon Ekklession [Elements of Natural Lighting in the Byzantine Churches] (Athens:Division of Antiquities and Restoration, 1964). In this work professor Triantafyllides studied the lighting conditions of certain Byzantine churches using a light meter and taking systematic measurements of light intensity at predetermined locations within a number of Byzantine churches. In doing this, he chose a time of day which did not interfere with the liturgy. This work, although valuable, acknowledges no relationship of the lighting conditions to the liturgical sequence.

²⁶ Grumel, Traité d'Études Byzantines I: La Chronologie : 175-6.

²⁷ Encyclopedia Britannica 15 (1980): 429-30.

²⁸ This computer program was developed by the Professor of Astronomy Richard Sears of the University of Michigan who served as a member of this dissertation committee. The method of calculation is described in Appendix 3.

CHAPTER IV

HISTORICAL PRECEDENTS AND THE BYZANTINE ARCHITECTS' AWARE- NESS OF LIGHT

The use of light in Byzantine churches, as outlined above, is not without precedent. Most ancient civilizations sought to embody their cosmological beliefs into some of their most representative buildings. They incorporated their knowledge of the motion of heavenly bodies in these buildings, since these were thought to bear a relationship to the divine order. This has been found to be true in the Passage Graves of Ireland, ¹ in the Megalithic Monuments of Britain and France, ² as well as in the Temples of the Egyptians, ³ the Mayans, ⁴ and the Kambodians.⁵

This chapter examines the general context of temple design, in respect to light, inherited by Byzantine architects. By looking into the potential relationship between the temple and the church certain striking similarities are discernible in the uses of natural light that can be traced from the Classical Greek Temple, and the Roman Pantheon through the Early Christian experimentations to the Byzantine Church. ⁶

The rules governing the use of light in religious buildings appear to have undergone a slow development during these periods. The direction of sunlight at the time of celebration of the liturgy and the evocative effect on the viewer seem to have determined the main axis of the plan, while a second axis of guided light fixed the location of the image of the deity vertically and established a connection with the heavens. These two axes were so interrelated as to ensure that the image of the deity was kept at a distance from the viewer. Moreover, in both cases elaborate devices involving natural light were invented to ensure that the imagination of the faithful would be caught and awe would be inspired.

However similar in principle, though, one could hardly recognize any aesthetic similarities of effect between the Greek temple and the Byzantine church. The reason for

this is that the manipulation of the two axes of light underwent a development and was in each case responsive to the specific liturgical needs.

It is likely, although it cannot be definitely established, that Byzantine architects made a conscious connection between their designs and those of classical temples. Indeed, there is evidence that they were not only aware, but themselves part of a nearly continuous development in the sciences of astronomy, optics, and mathematics, which constituted an essential part of architectural education, until at least the 6th century A. D.

The Approach to Lighting in Greek Temples

Regarding the spatial orientation of Classical Greek Temples, two theories have been advanced. The English architect F.C. Penrose proposed that each classical temple was oriented toward the rise of a specific constellation just preceding sunrise on the deity's feast day.⁷ According to Penrose, "in the earlier ages of Greek civilization the only accurate measure of time by night was obtained by the rising or setting of stars, and these were more particularly observed when they were heliacal, that is, as nearly as possible to sunrise. For the purpose of temple worship, which was carried on almost exclusively at sunrise, the priests would naturally be very much dependent for their preparations on the heliacal stars as time warners."⁸ Penrose attempted to justify, on the basis of his theory, dates for the construction of temples that were usually much earlier than the ones accepted by archaeologists.⁹

In contrast, the American archaeologist William Bell Dinsmoor, advanced a theory that most Greek temples are oriented toward the rising sun of the deity's feast day in the year of the temple's dedication.¹⁰ In this theory, which is the most widely accepted today,¹¹ Dinsmoor attempted to reconcile astronomical and archaeological data with information regarding the religious cult and the locally used calendar. He was able to prove that the Parthenon, at the time of its construction, was oriented exactly toward the rising sun on the birthday of the Goddess Athena and the moment in which the

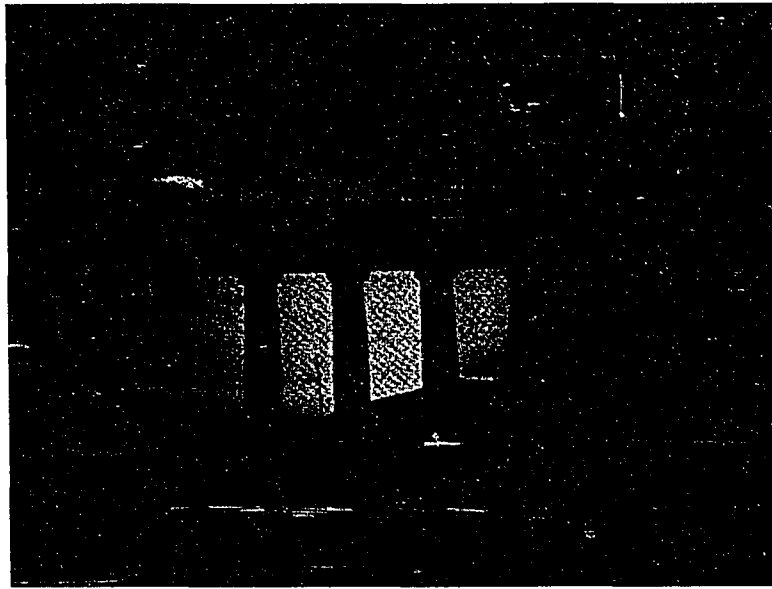


Fig. 4.1 Sunrise on the Parthenon, August 23, birthday of goddess Athena

Panathenaic procession began (Fig. 4.1).¹² His theory applies to most known temples.¹³

These two theories indicate quite different intentions on the part of the architect. Penrose's theory implies that the orientation of a temple was based on purely utilitarian considerations, that is, the observation of stars simply as time warners. But he does not present a convincing reason as to why the priests would need to observe the stars from the adytum, since this could take place equally well outdoors; neither does he take into account the existence of water clocks that were in use for time measurement at night.¹⁴ Dinsmoor's theory, on the other hand, is related to an aesthetic, awe-inspiring effect at the time of sunrise, which was of decisive significance for the religious service.

The interior of the temple was most probably open only to privileged persons, and the one and only view which most other people had of the statue of the deity was through the open doorway to the east. One can, under such circumstances, have some idea of the awe and sense of mystery inspired among them by such a view of the image of the deity.¹⁵ A passage by Aeschylus describes the probable intended effect of receiving the first rays of sunlight through the front door on the deity's feast day: "Gods [would] face the

rising sun . . . with gleaming eyes.”¹⁶ Channeling sunlight through the central columns and the door opening, which often was the only opening to the adytum, would create a dramatic, animating effect on the statue of the deity which was housed within the temple. The eyes of the statue, would have appeared to come to life radiating with an unearthly gleam.

There has been much debate regarding a secondary opening on the roof, called “*opaion*,” which could refer to the clerestory formed by a lantern projecting above the roof, or to a hypaethral opening in a roof, or even to holes pierced in a single tile.¹⁷ The very definition of the term indicates that an *opaion* was a quite versatile device for the manipulation of light.

According to Dinsmoor, hypaethral temples did exist but they were rare.¹⁸ In opposition to Cockerell, he rejected on aesthetic grounds the idea that a hypaethral opening in the roof had been frequently used because, as he said, it would have had a very ugly effect from the exterior with its notch in the ridge line.¹⁹

However, there is evidence that in some cases a special translucent marble was used for roof tiles in order, perhaps, to add to the illumination of the interior of the cella, through openings of the framed ceiling.²⁰ In addition to this, a few special tiles with elliptical openings (or rectangular openings with round corners) were used for illumination. Tiles with similar pierced openings surrounded with projecting rims and occasionally provided with marble lids have been found at a number of temples.²¹ But these openings, according to Dinsmoor, were so small that they could not have constituted a system of lighting for the interior of the cella and were probably intended merely for the lighting and ventilation of the storage space in the attic during the rare intervals when this was visited.²² In my opinion, an *opaion* and pierced and translucent tiles were probably used to establish a secondary vertical axis of illumination (Fig. 4.2). Especially, the form of the pierced holes and the existence of lids over them appear to be much too elaborate for merely lighting an attic which would hardly ever be visited. Given the difficulty of

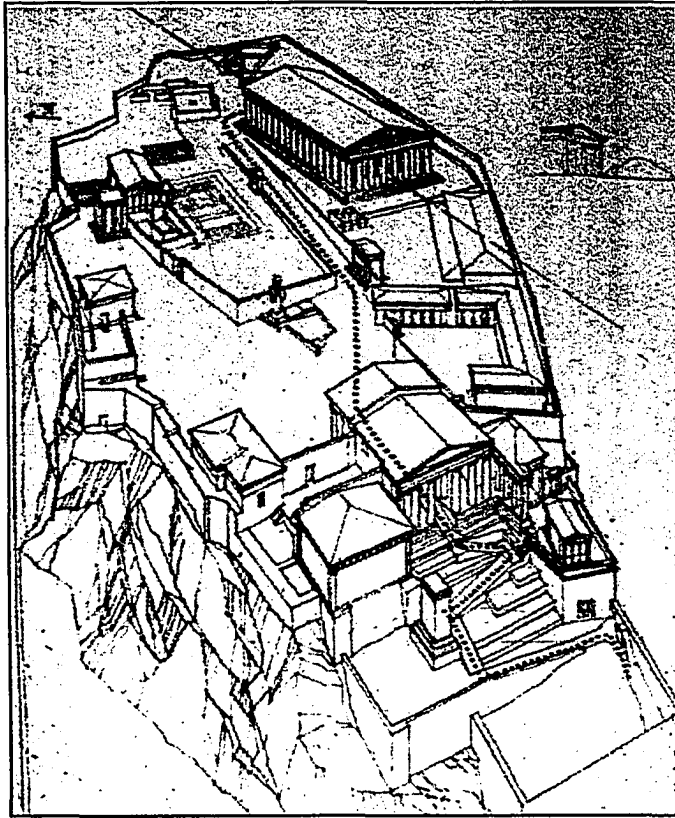


Fig. 4.2 Acropolis, Athens, Reconstruction

constructing such elliptical openings on tiles, it appears that their purpose was to direct light with considerably higher precision, the lids being used to carefully control the direction and intensity of natural light for the creation of awe-inspiring effects. The writings of Diocles and Heron of Alexandria give evidence of a strong interest in sophisticated effects of this kind, requiring high degrees of precision.

In the work “On Burning Mirrors,” of the mathematician Diocles (2nd century B.C.²³) descriptions of some amazingly complex mirror configurations are found. Among his dealings with theoretical constructions of, for instance, parabolic focusing reflectors, or of a sundial that could indicate the hours by burning a trace on a certain material²⁴ etc., Diocles observes:

We believe that it is possible to make a burning-instrument of glass such that it has a special property, namely that one can make lamps from it which produce fire in temples and at sacrifices and immolations, so that the fire is clearly seen to burn the sacrificial victims; this occurs, as we are informed, in certain remote cities, especially on the days of great celebration: this causes the people of those cities to marvel. That is something which we shall do. ²⁵

Many examples of the use of scientific principles to produce “miracles,” especially in temples, are found in Heron’s (1st century AD ²⁶) work “On Pneumatics” which was largely a collection of inventions that had been developed in earlier times. ²⁷ In one of these inventions, statues of human figures are made to appear to offer libations automatically when fire is kindled on the altar (Fig. 4.3); ²⁸ in another case, the same thing happens while a snake hisses (Fig. 4.4); ²⁹ elsewhere, the sound of a trumpet is triggered by the opening of the doors (Fig. 4.5); ³⁰ Heron describes, at another point, a device used in Egyptian Temples by means of which those who enter appear to be sprinkled and purified with holy water (Fig. 4.6); ³¹ in another case, the doors of a temple are made to open automatically when a sacrifice is burned on the altar and once the fire is extinguished the doors close again (Fig. 4.7). ³²

Heron also wrote a *Catoptrica*, a treatise on Catoptrics, which contains problems for the construction of mirrors or combinations of mirrors capable of reflecting objects in a particular way. These include the con-



Fig. 4.3 Heron on Pneumatics. Automaton, Human figures offering libation

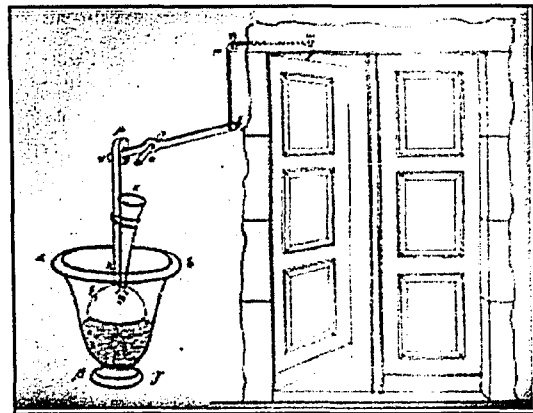


Fig. 4.5 Sounding trumpet at the opening the door. Heron on Pneumatics

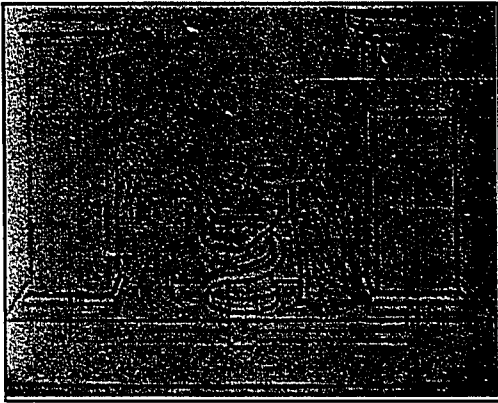


Fig. 4.4 Automaton. Offering of libations while a snake hisses. Heron on Pneumatics

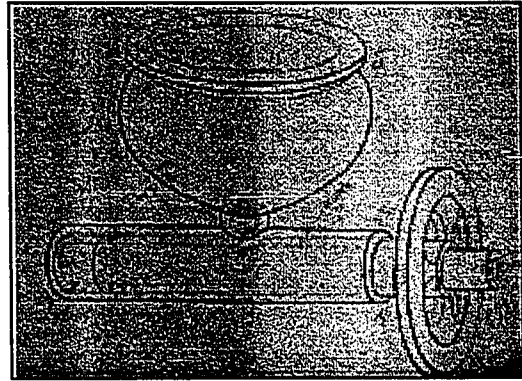


Fig. 4.6 Automatic sprinkling with holy water. Heron on Pneumatics

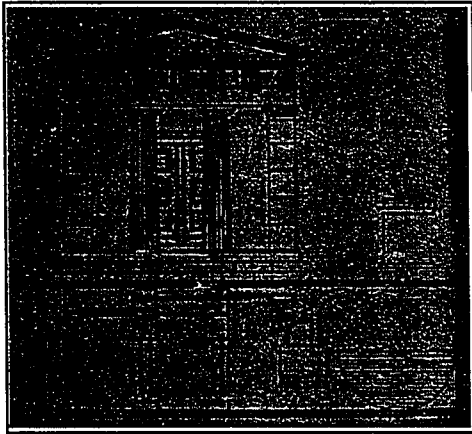


Fig. 4.7a Automatic opening of the doors, when sacrifice is burned on the altar. Heron on Pneumatics

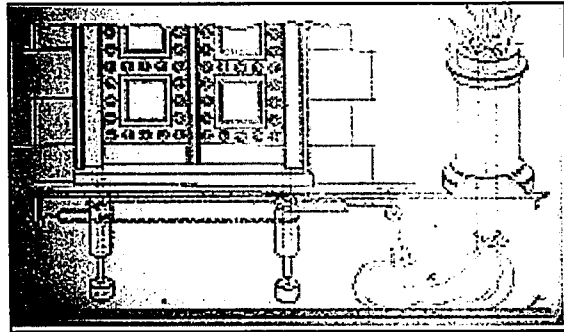


Fig. 4.7b Detail

struction of a mirror called *polytheonon* ("with many images"). One of the uses of this mirror was to display the birth of Athena-Pallas from the head of Zeus by blending the images (Fig. 4.8 a, b, c). It could also make the right side appear as right in the picture (instead of the reverse) or a single finger appear as many, or cause the head of an ox to appear as doubled;³³ or make a man appear in the mirror with head downwards; with face distorted; with three eyes or two noses etc.

Another mirror configuration described in Heron's work would enable a person to

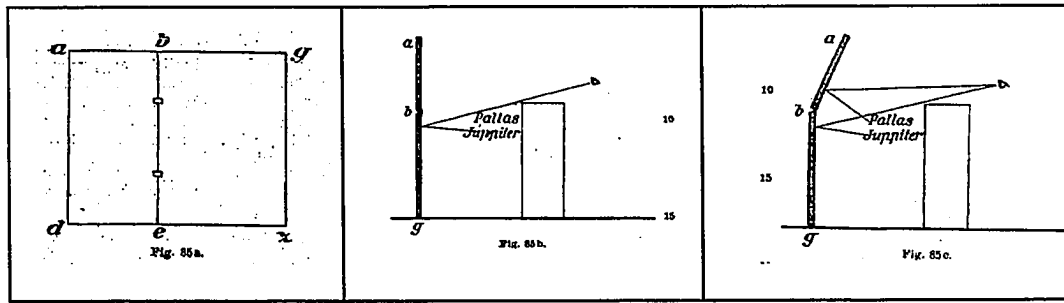


Fig. 4.8 a,b,c Visual effect simulating the birth of Athena from Zeus's head. Heron Catoptrica.

see his back (Fig. 4.9 a, b).³⁴ In another case a mirror is described which is placed inside the window of a house, so that one can while inside the rooms see in it everything that passes in the street (Fig. 4.10).³⁵ Heron also shows a method to arrange mirrors in a given place so that a person who approaches cannot actually see either himself or any one else but can see any image desired (a "ghost-seer"). This configuration, it is explained, was intended to be placed in a Temple so that when one approached the altar one would see suddenly the apparition of the deity as if emerging through the wall. The statue

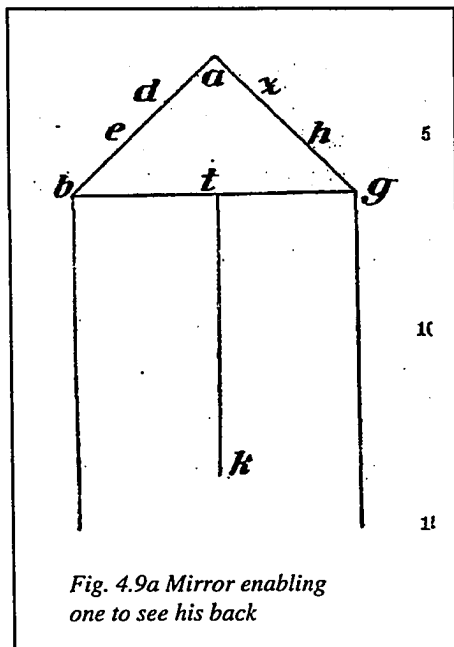


Fig. 4.9a Mirror enabling one to see his back

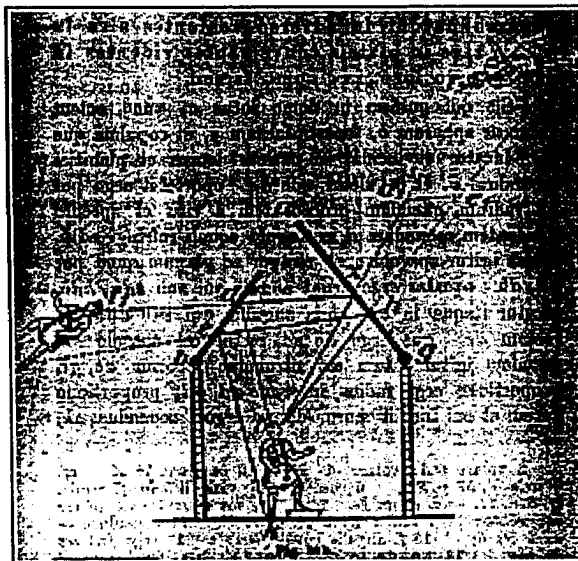


Fig. 4.9b Geometrical proof of mirror configuration Heron Catoptrica

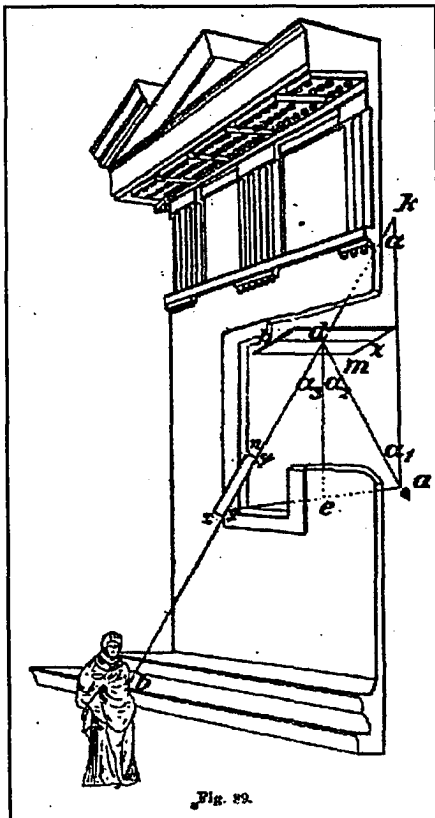


Fig. 4.10 Mirror that enables one to see from inside the house everything that passes on the street.

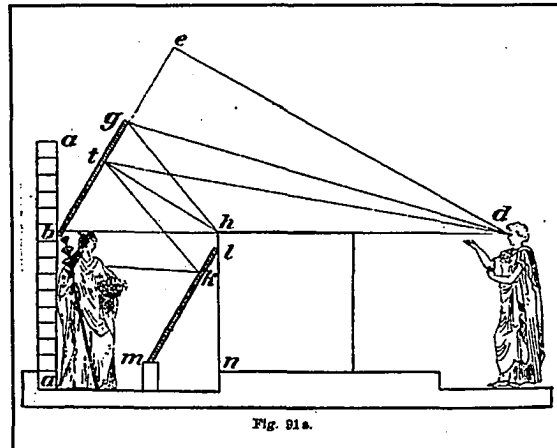


Fig. 4.11a Mirror configuration for creating the illusion that God appears miraculously
Heron Catoptrica

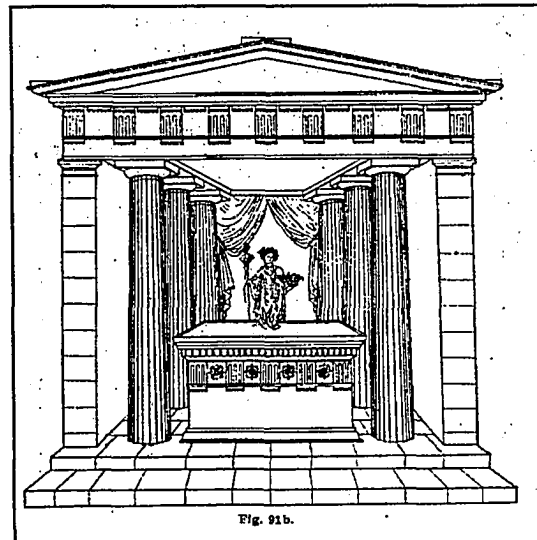


Fig. 4.11b Perspective view of the above.
Heron Catoptrica

supplying the reflection would be hidden from sight and lit by a concealed side-window so that the apparition would be made to appear bright and shining while the edges of the mirror were carefully concealed by drapery (Fig. 4.11 a, b).³⁶ Concave and convex cylindrical mirrors played a part in these arrangements.³⁷

Ingenious tricks of this kind presuppose not only an accurate understanding of the

movement of light or of “visual rays” (by means of which the generation of images in the eye was explained in antiquity) but displays a vigorous creativity which can only result from long exposure to and a facility with a certain medium, in this case mirror configurations. It is evident from the above examples that these designs were closely related to the needs of religious architecture and often constituted designs specifically invented for use in temples.

The design of natural lighting in Greek Temples depended, therefore, on the orientation of the central axis of the temple plan and at times perhaps on a secondary vertical axis marked by an *opaion* which was probably placed above the statue of the deity.

The use of two axes seems to have persisted through the Roman period and to have found expression in churches of the Early Christian and Byzantine periods in a considerably modified manner. Apart from these two axes certain more complex configurations of openings may have used natural light in conjunction with special devices in order to inspire awe.

Vitruvius (1st century BC) informs us that in Roman times temple orientation was also understood in relation to the motion of the sun and that a visual, awe inspiring effect was sought.

The quarter toward which temples of the immortal gods ought to face is to be determined on the principle that, if there is no reason to hinder and the choice is free, the temple and the statue placed in the cella should face the western quarter of the sky. This will enable those who approach the altar with offerings or sacrifices to face the direction of the sunrise in facing the statue in the temple, and thus those who are undertaking vows look toward the quarter from which the sun comes forth, and likewise the statues themselves appear to be coming forth out of the east to look upon them as they pray and sacrifice.³⁸

Elsewhere Vitruvius states:

Altars should face the east, and should always be placed on a lower level than are the statues in the temples, so that those who are praying and sacrificing may look upwards towards the divinity.³⁹

However, according to Dinsmoor, Vitruvius's statements do not represent main-

stream practice. But in those few cases (some, identified by Dinsmoor) that followed Vitruvius's description, that is, temples faced toward the West rather than the East, an opaion of some kind would have been absolutely essential if the images of the Gods were to be seen at all in the morning.

The vertical axis of light receives more attention in Roman times. The *oculus* of the Pantheon is a good example of this. But also a third effect, that of the interior of a religious building viewed as a “roofed spherical dial,”⁴⁰ may also have been at work here, especially considering that the Pantheon was filled with statues of planetary gods (Figure 4.12 a, b).

The initial conceptions of spatial orientation in Early Christian Churches seem to have been influenced by earlier ideas and religious practices. However, this influence seems to have been subjected to a gradual process of intense experimentation, as Lockyer has suggested,⁴¹ and as may be gathered by the widely varying orientations of Early Christian churches.

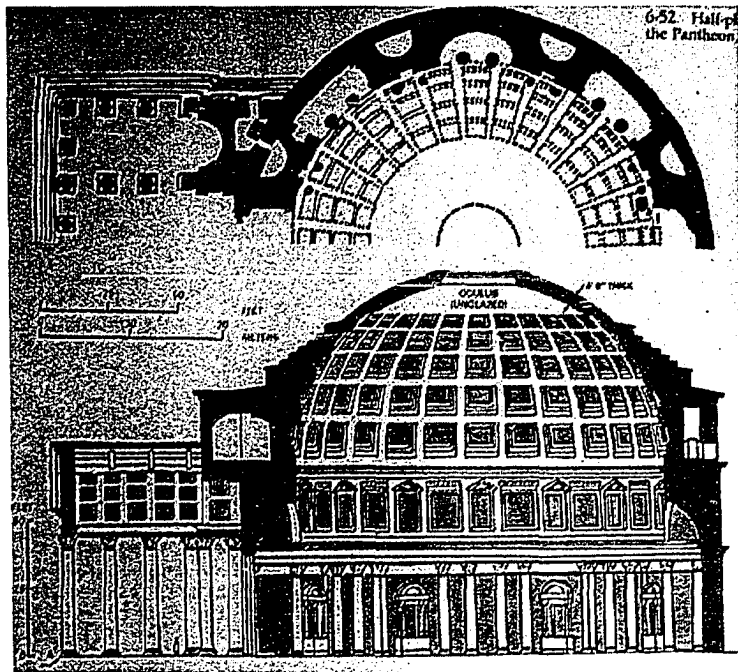


Fig. 4.12a
Plan and
Section of
Pantheon,
Rome



Fig. 4.12b
Interior per-
spective
reconstruction
Pantheon,
Rome.

The whole of the roof of a Basilica has been referred to by Michelis as a continuous *opaion*.⁴² Two-dimensional, pictorial representations of *oculi* or *opaia* often mark the center of the nave ceiling (Fig. 4.13) or the quarter-sphere of the apse in Early Christian Basilicas. Into these, representations of a radiant Christ are painted which are often enveloped by a brilliant “glory” (Fig. 4.14) or sometimes a representation of a cross is seen on a star-studded, deep blue sky (Fig. 4.15).⁴³ The two axes of light seem to persist but there seems to be some uncertainty in regards to the determination of their exact position.

Byzantine Modification of the Traditional Practice

The scientific endeavors and inventions of the Greeks were not unknown to the early Byzantines. It appears, however, that the connections with antiquity were not limited only to the ability to contrive and mathematically prove the properties of various mechanical and optical devices. The large picture points to an attitude which both civilizations seem to share—that of placing subtle effects and technological contrivances in



Fig. 4.13 Basilica. St. Apollinaire Nuovo, Ravenna

service of religion, which aimed at enhancing a perception of the divine order. This was accomplished by following a systematic yet profoundly aesthetic approach on the part of the architect.

Regarding the Byzantine churches, it is commonly supposed that their apse should be oriented toward the East. However, a considerable divergence from this rule has been observed in most Byzantine churches. A comprehensive theory has yet to be proposed to account for their varying orientation.

The point of view presented here places the Byzantine church design within both a liturgical and historical context. The axis of the plan was determined in both the Classical Temple and the Byzantine Church by what was planned to be the sudden perception



Fig. 4.14 Pictorial oculus or opus. Christ enveloped in "glory"

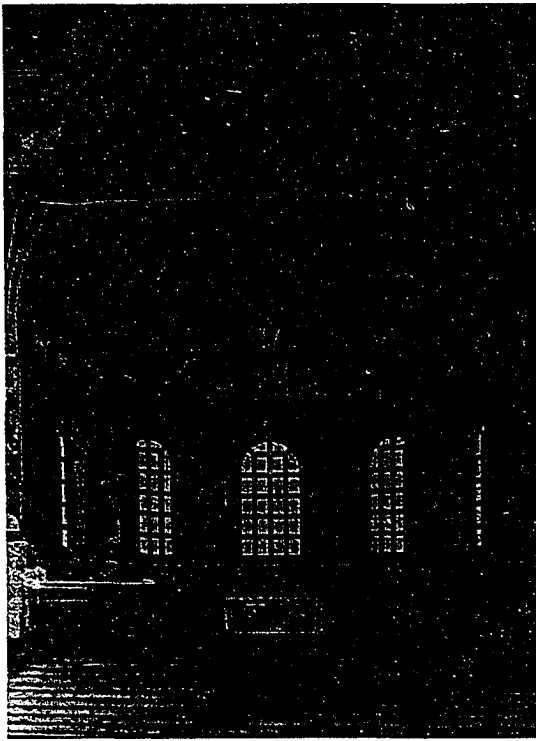


Fig. 4.15a Apse with painted oculus.
Classe, St. Apollinaire

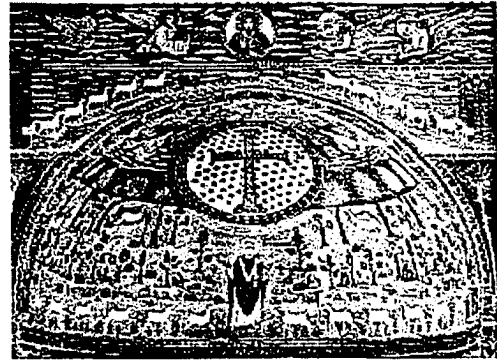
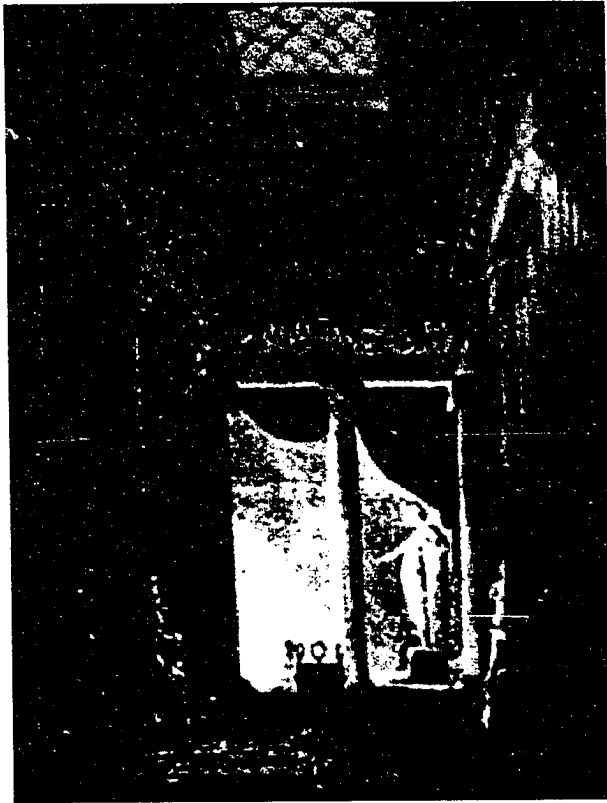
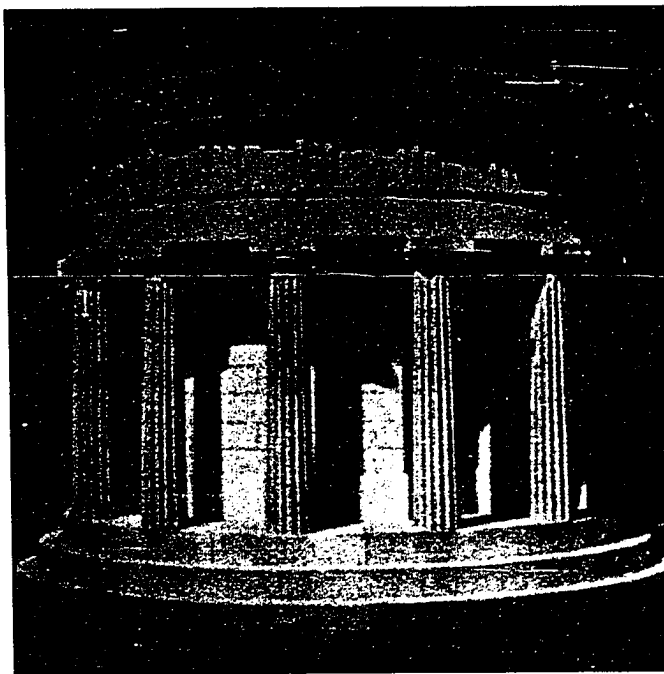


Fig. 4.15b Detail

of a divine action, an awe inspiring event which would immerse the observer into a divine world. This event takes place at the time of the most sacred moment and is related to the feast day associated with the particular building. In both cases the orientation is determined by sunlight and the time of the liturgy. However, the time of the liturgy differs between the two, being the moment of sunrise for the temple and the mid-morning hour for the church. In the case of the Byzantine church, the main horizontal axis shifts from the direction of sunrise to the mid-morning sun position of the day of the celebration of the church, since it is the mid-morning now which becomes liturgically most significant.⁴⁴ The vertical axis of light is now intensified visually not by an oculus but by the highly and constantly illuminated apex of the dome (which may be seen as similar to an *opaion-lantern* type of opening of an ancient temple (Fig. 4.16). Light appears to emanate from Christ Pantocrator or the dwelling of God located there. The “roofed



*Fig. 4.16 Bassae:
Interior of Temple
of Apollo,
Looking south.
Central location of
opaio*



*Fig. 4.17 Delphi
Old tholos
(restored by Permtow)
with indication of
lantern on top*

spherical dial” effect of the Pantheon is transformed and refined in the Byzantine church by the need for admitting light through windows in the sides of the dome (Fig. 4.17). The vertical axis appears to have undergone great development between the two periods. The image or locus of God has been moved from the intersection of the two axes to the end of both axes instead of the statue of god in the temple, there is a position that signifies the divine presence in the church. Moreover, the image of the deity, instead of being lit, is perceived as distributing light. God has become the generator of light rather than the receiver (even though the Classical experimentations with certain *opaia* and translucent materials used on the roof may have aimed at a similar goal). Finally, ingenious devices manipulating light in an appropriate manner appear to have been employed in both cases,⁴⁵ but the effects in the case of the church appear to be more refined and esoteric. Thus, the manipulation of light seems to have reached a revolutionary inventiveness in the Byzantine period, still retaining certain Classical attributes. Specifically, practices pertaining to the admission of light shafts on the altar appear to have been crystallized by the fifth century after undergoing a period of experimentation until the end of the fourth century. The light effects in the dome must have been used from its first implementation and they must have constituted one of the principal reasons for its employment. It would be interesting to trace the evolution of the lighting design and the exact circumstances of major conceptual changes and transformations. However, such an inquiry far exceeds the scope of the present work, whose objective is to establish some fundamental commonalities among the practices of major historical periods.

Christian religion seems to have achieved a clear expression in Byzantine architecture not by breaking away from Classical tradition, but by constantly elaborating and refining it. From a scientific point of view no new discoveries were involved. But, architecturally, a conceptual move forward was made evident by the appropriate architectural adaptation of known principles. It will become progressively evident that the inventiveness of the Byzantine architects, mentioned above, reaches its apogee with Hagia Sophia

of Istanbul. However, the conceptual basis of the design even in lesser church examples still retains these revolutionary qualities even though not realized with the technical expertise found in Hagia Sophia. The ingenious implementation, for instance, of reflected light onto the apex of the dome is brilliantly associated with church canon resonating at the same time earlier practices of *occuli* or *opaia*.

The keen interest in the evocative potential of light was kept in later built expressions of Christian religion, such as in the Gothic cathedrals, in the Cistercian monasteries, in the Baroque churches. Traces of similar attitudes may be detected even in the 19th churches of England and Germany.⁴⁶

The Byzantine Architects' Awareness of Light

The education of the Byzantine architect interests us here only insofar it pertains to the general theme of this dissertation. Certain studies conducted by modern scholars have dealt with questions regarding the curriculum of architectural training, while others discuss prevalent scientific interests during the antique, late antique, and Byzantine eras. Some general points that have been elucidated in these studies indicating the extent of the architects' knowledge on the subjects of astronomy and the motion of light one thus examined in this chapter. In addition, an excerpt from Anthemius's extant writings is also analyzed in order to clarify the degree to which the architects of that period could, in fact have been capable, willing, and facile in undertaking the task proposed by the hypothesis of this dissertation. Moreover, the potential relationship of this excerpt to the original dome of Hagia Sophia is also discussed.

Architectural Training and the Profession

Since ancient times the architectural profession was highly regarded and certain subjects seem to have been considered fundamental to a complete architectural education. Pytheos (4th c. B.C.), the architect of the temple of Athena at Priene⁴⁷ and of the Mausole-

leum of Halikarnassos - - considered one of the seven wonders of the world ⁴⁸ - - indicated that the requirements for architectural training were quite stringent in Classical Antiquity. Pytheos envisioned the architect as an all round expert.

The architect ought to be able to accomplish more in all the arts and sciences than the men who, by their own particular kinds of work and the practice of it, have brought each a single subject to the highest perfection.
49

Vitruvius (1st c. B.C.), in his treatise on architecture, enumerates a great many skills and fields of knowledge as being expected to be mastered by an architect. He sees the architect as being:

. . . educated, skillful with the pencil, instructed in geometry, know much history, have followed the philosophers with attention, understand music, have some knowledge of medicine, know the opinions of the jurists, and be acquainted with astronomy and the theory of the heavens. ⁵⁰

In the Hellenistic period Geminus (1st c. A.D.) ⁵¹ presents a curriculum for architectural training that required extensive knowledge on both theoretical and applied subjects. This included mechanics proper, applied perspective, optics, catoptrics (or the theory of mirrors) ⁵², the art of making engines of war, the art of making miraculous machines, sphere-making (the imitation of the movements of the heavenly bodies), astronomy (which was subdivided in sundial making, star position measurement, determining relative positions of the sun, the moon and the stars) etc. ⁵³ Specifically, Geminus considered catoptrics as being a branch of optics and applied perspective as part of the general science of mechanics. ⁵⁴

Pappus of Alexandria (4th c. A.D.), ⁵⁵ discusses the education of the architect in terms quite similar to Vitruvius. A clear distinction between architectural theory and practice, for example, is found in Vitruvius as well as in Pappus. They both indicate that mastery of these two aspects was indispensable to a complete architectural training. ⁵⁶ Vitruvius' requirements, however, include certain legal, historical, medical, and philosophical aspects not found in Pappus. Relying on the practice followed in Heron's school (1st c. A.D.), ⁵⁷ Pappus maintains that architects should be proficient in geometry, arith-

metic, astronomy and physics, among other subjects.⁵⁸

According to Richard Krautheimer, Anthemius and Isidorus, the architects of Hagia Sophia of Constantinople, were not architects but scientists who turned into architects when the situation called for it.⁵⁹ This opinion is chiefly derived from the term “mêchanikoi” or “mêchanopoioi”⁶⁰ the term Procopius used to describe them, and which has often been translated as “engineers” or “mechanical engineers.” The historian Glanville Downey, on the other hand, maintains that these same individuals had received an architectural training of the highest kind.⁶¹ According to Downey, Pappus presents the optimum curriculum of architectural studies and shows that what one should call the profession of architecture was known as “mêchanikê.” Architectural studies seem to have grown out of the study of “mechanics” and an “inventor of mechanical devices” actually meant what one should call an architect.⁶² The term “mêchanikos” to denote an architect must have grown out of the importance that engineers assumed during Roman times.⁶³ Also Procopius⁶⁴ made it clear that Justinian put Anthemius in charge of the new Hagia Sophia because he was “the most learned in the art of building” and Agathias⁶⁵ described him as a “builder by profession.”⁶⁶

The range of knowledge obtained by an architect in antiquity is impressive by modern standards. However, it must be noted that architects did not confuse themselves with scientists. Vitruvius, for instance, thought of himself not as a specialist in astronomy or dialing but rather as a generalist and saw mathematicians as having a higher standing than architects.

As for men upon whom nature has bestowed so much ingenuity, acuteness and memory that they are able to have a thorough knowledge of geometry, astronomy, music, and the other arts, they go beyond the functions of architects and become pure mathematicians . . . Such men, however, are rarely found, but there have been such at times; for example, Aristarchus of Samos, Philolaus and Archytas of Tarentum, Apollonius of Perga, Eratosthenes of Cyrene, and among Syracusans, Archimedes and Scopinas, who through mathematics and natural philosophy discovered, expounded, and left to posterity many things in connection with mechanics and with sundials.⁶⁷

Vitruvius implies a meaningful connection here between the architect and the mathematician. A mathematician is one who has mastered what an architect must, but has been able to go beyond and expound on these by distilling the theoretical essence and becoming a pure scientist; that is, he has moved beyond the limitations of the particularities of applied cases to the comprehension of basic principles. He also maintains the connection of the mathematician to mechanics and sundials, found earlier for the architect.⁶⁸

According to Heath, the approaches and methods used by Heron, as well as Anthemius and Isidorus, evidenced a tendency toward practicality or the influence of lifelong practical knowledge. Heron in his writings presented mathematics and mechanics in a form convenient for practical purposes.⁶⁹ He is mentioned by Pappus as being head of a school of *mechanicians*.⁷⁰ Heath maintains that Heron's works were intended for engineers, architects and craftsmen⁷¹ and another one asserts that Heron was eminently practical.⁷² Heron's works were in regular use in Greek, Roman, Byzantine, and Arabian education for centuries and they were repeatedly re-edited and constantly used.⁷³

According to Cameron, Anthemius, for an architect, was no doubt a competent mathematician, and he certainly knew how to apply his knowledge to subjects great and small.⁷⁴ About Isidorus, Cameron states that there is no reason to doubt that Isidorus was a practicing, professional architect all his life, teaching pupils in the intervals between commissions.⁷⁵

This practice-oriented and case-specific disposition is at odds with a purely scientific or theoretical approach which tends to resolve problems in their more general and inclusive form rather than in limited or non-representative special cases. Conversely, the case-specific is, clearly, an approach that an architect would employ because of the applied nature of his subject.

Astronomy and Dialing

Vitruvius points out the need for a knowledge of optics and astronomy because:

By means of optics the light in buildings can be drawn from fixed quarters of the sky. ⁷⁶ . . . (while) from astronomy we find the east, west, south, and north, as well as the theory of the heavens, the equinox, solstice, and courses of the stars. If one has no knowledge of these matters, he will not be able to have any comprehension of the theory of sundials. ⁷⁷

Vitruvius devotes his ninth book to astronomy, astrology, and the construction of time-pieces. He analyzes in detail the course of the sun, the moon, the planets, and the constellations of the zodiac. This analysis is followed by a detailed explanation and method of construction of the *analemma* as well as analyses and construction methods of various sundials and water clocks capable of showing the seasonal hours. All this detailed discussion indicates that late antique architects studied astronomy and time-keeping, extensively and they were aware of the movement of heavenly bodies including the sun, the moon, the planets, and the constellations in minute detail. The discussion of the *analemma* by Vitruvius shows their awareness that typical sundials were location-specific.

Hence, it was by no means unusual for architects to deal with the study and construction of time-pieces. In fact, detailed information related to the various types of time-pieces and directions for their construction are included in Vitruvius' treatise on Architecture. ⁷⁸ The study of astronomy, astrology and the construction of time-pieces appear to fall within the same broad category, and they are thought to constitute an indispensable part of architectural education. ⁷⁹ It appears, then, that architects from the Classical to the Byzantine period were expected to possess a thorough education in astronomy probably in order to be able to contrive a meaningful relationship between the structures they designed and the order of the universe, to which very close attention was paid, as well as to fulfill requirements of function and well-being. It is clear, then, that one of the major uses of astronomy for architects was the comprehension and construc-

tion of sundials. A working knowledge of the motion of light was, therefore, central to architectural practice.

The work that remained the state of the art in astronomy at least until the Renaissance was Ptolemy's (2nd c. A.D.) *Almagest* composed in 13 books.⁸⁰ Ptolemy also wrote the *Tetrabiblos* (four books), which was a systematic treatment of astrology.⁸¹

Philosophers were also actively involved in the study of astronomy and mathematics because these were the sciences par excellence that facilitated the rational comprehension of the universe to which philosophers aspired. They wrote numerous commentaries and original works. The chief representatives of the Neo-Platonist school of philosophy, both in Athens and Alexandria, were interested in many ways in astronomy and mathematics. Porphyry (A.D. 232-304)⁸² - - the disciple of Plotinus - - Iamblichus (died A.D. 330)⁸³ - - Porphyry's pupil - - Proclus (A.D. 412-485),⁸⁴ the most important of the Neo-Platonists in respect to mathematics⁸⁵ and director of the Neo-Platonic Academy in Athens, all wrote original works and commentaries on mathematics and astronomy. According to Heiberg, most of these publications of and commentaries on works of mathematics are found before the closing of the University of Athens in 529 A.D. by Justinian⁸⁶ but shortly after as well.

Optics and Catoptrics

The study of optics and catoptrics had been of great importance to the curriculum of architectural education as well. The active interest on these subjects exhibited in classical Greek and Hellenistic times continued undiminished through the early Byzantine period. This interest, however, was expressed less in original works and mostly in commentaries on ancient treatises.

The study of the properties of mirrors goes at least as far back as Plato. The first indication of a science of optics which includes a discussion of mirrors is found in his *Timaeus*.⁸⁷ It constituted a subject dear to philosophers since it dealt directly with the

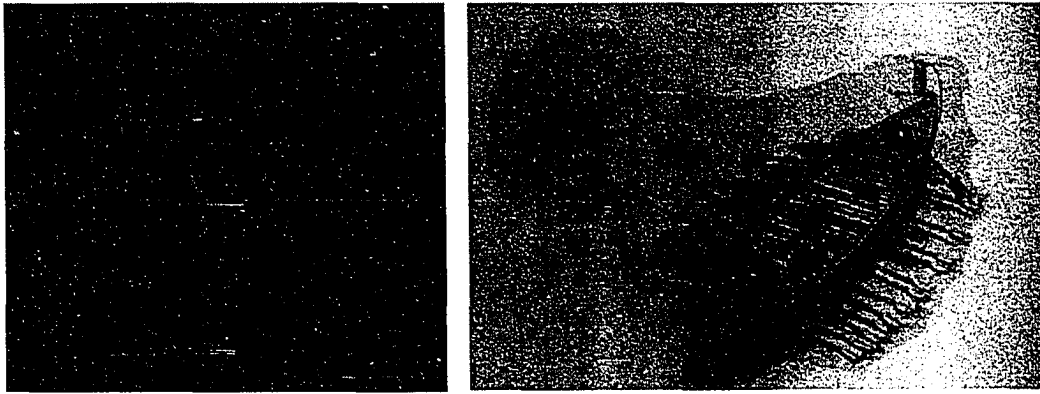


Fig. 4.18, 4.19 Archimedes' burning of the Roman ships at Syracuse.
Experiment conducted by I. Sakkas, has proven it possible

human powers of visual perception through which reality was accessed by the human mind. But soon pure scientists systematized the study of this subject. Euclid (flourished around 300 B.C.) wrote on *Optics*.⁸⁸ Archimedes (287-212 B.C.)⁸⁹ wrote on *Catoptrics*⁹⁰ and was reputed to have burned the Roman ships at Syracuse (Fig. 4.18, 4.19).⁹¹ Apollonius of Perga (probably born 262 B.C.)⁹² wrote *On the Burning Mirror*.⁹³ Diocles (2nd c. B.C.) wrote on *Burning Mirrors*⁹⁴ and Geminus (1st c. A.D.) wrote, perhaps, on catoptrics as well.⁹⁵ Heron (1st c. A.D.) wrote the very influential treatises *Catoptrica* and *Dioptra*.⁹⁶ A discussion of the kinds of problems contained in Heron's *Catoptrica* is discussed in the previous chapter. Concave and convex cylindrical mirrors play a part in these arrangements.⁹⁷

Ptolemy of Alexandria (2nd c. A.D.)⁹⁸ wrote his highly influential *Optics* in five books the third of which was on *Catoptrics*.⁹⁹ In this work he deals with plane, concave and convex mirrors, binocular vision, visual impressions, color sensation, optical illusions, and refraction.¹⁰⁰

Commentaries

Pappus of Alexandria (4th c. A.D.)¹⁰¹ included Euclid's work on *Optics* in his *Little Astronomy* and commented upon it.¹⁰² Theon of Alexandria (4th c. A.D.).¹⁰³ produced several commentaries and editions of older mathematical works such as those of Euclid, Archimedes, Heron, Olympiodorus and Ptolemy¹⁰⁴ in order to supplement the curriculum of the school of Alexandria and he also wrote a *Catoptrica*.¹⁰⁵

Isidorus and his colleague, Anthemius of Tralles, paid considerable attention to early Greek mathematics and mechanics partly at least owing, according to Heiberg, to the gigantic task of vaulting Hagia Sophia. Isidorus of Miletus (6th c. A.D.) republished some of Archimedes's work. He also revised the commentaries of Eutocius on Archimedes's works and it was in Isidorus' school that these treatises were turned from their original Doric into the ordinary language, with alterations designed to make them more intelligible to elementary pupils.¹⁰⁶ A pupil of Isidorus composed a significant treatise on solid geometry, which has been passed off into Euclid's *Elements* as Book XV.¹⁰⁷

Eutocius, who flourished about A.D. 500 and seems to have been head of the Neoplatonic school of Alexandria until A.D. 550,¹⁰⁸ wrote commentaries on Archimedes's the *Measurement of a Circle* and on the *On the Sphere and Cylinder*. He also wrote commentaries on Apollonius' *Conics*, which he dedicated to Anthemius,¹⁰⁹ He also mentions the mathematician Diocles (2nd c. B.C.),¹¹⁰ appearing to know his work well.¹¹¹ Isidorus was either a younger contemporary of Eutocius or Eutocius was Isidore's student.¹¹² If Eutocius, works were edited by Isidorus' pupils or if Eutocius was Isidorus' pupil may mean that the *Conics* were in use by Isidorus as textbooks. Diocles's work also might have been known to Isidorus since Eutocius commented on it. Diocles's work was most probably known to Isidorus through Eutocius's commentaries on Archimedes¹¹³ and Isidorus's invention of a special compass for drawing parabolas, a

quite unusual instrument, ¹¹⁴ may be related to an interest in parabolic burning mirrors. Isidorus of Miletus also knew Heron's work because he studied Heron's book *On Vaults*, and published a commentary on it. ¹¹⁵

Anthemius (6th c. A.D.) wrote on curious machines and, among other things, dealt with burning-glass and criticized with technical knowledge the stories about the burning of the Roman ships at Syracuse. Anthemius might have known Diocles's work ¹¹⁶ through commentaries on it by Eutocius. ¹¹⁷ Eutocius was a contemporary and friend of Anthemius of Tralles. ¹¹⁸ Anthemius worked on very similar subjects with those of Diocles and used similar methods. ¹¹⁹ Therefore, Diocles's work might have been circulating in Late Antiquity. ¹²⁰ But, according to Toomer, there is no evidence that Anthemius knew of Diocles's work. ¹²¹ It appears, then, that at least the architects of the Early Byzantine period were directly schooled in the Greek and Hellenistic arts and sciences, being influenced by the antique approaches and methods. But architects and master builders of later periods as well must have had sufficient exposure to these depending on the level of their education. According to Glanville Downey the professional titles used for architects, engineers, master builders etc. reflected the level of their education and exposure in theory and practice. ¹²² The exposure to the Hellenistic tradition would have continued to a certain extent to be felt in later periods. According to Heiberg, the continuity of tradition in the Byzantine Empire was never broken by barbarian conquest, so that the treasures of the past were preserved. After the time of the Iconoclasts the University of Constantinople was restored and reorganized by the philosopher and mathematician Leo (9th century A.D.). Astronomy was always cultivated and in the 14th century it was revived due to Persian influence. ¹²³ As far as architectural education is concerned it has already been mentioned that the writings of Heron of Alexandria were in continuous use by the Byzantines but also in the Latin West and the Arabic countries at least until the time of the Italian Renaissance.

The above account indicates that architects and master builders throughout the

Byzantine period were sufficiently exposed to issues of astronomy, optics, and catoptrics and must have applied their knowledge each according to his individual level of skill. Hence, Anthemius' interest on the focusing reflectors was not incidental, but grew out of the fact that these aspects constituted an essential part of architectural education and practice. It is known, however, that highly educated architects were rare in the Byzantine world. Technical innovations proposed by architects according to the dictations of Church dogma and canon must have slowly crystallized and systematized into formulas or rules of thumb that were followed by common builders where no architects were available. According to Robert Ousterhout there is literary evidence of such systematized methods for the building of churches.¹²⁴ A similar system has been discovered by Nikos Moutsopoulos for churches of the Middle Byzantine period.¹²⁵ It is likely that the orientation and the system of lighting would have constituted part of such an easy to apply system.¹²⁶ The resolution of the problem of the exact manner in which these aspects of the design were communicated from the church authorities to the architects and builders far exceeds the scope of the present research. At this point, however, it would be suitable to present the manner and the degree of specificity and exactitude in which a problem for directing light within a building had been solved by one of the most celebrated Byzantine architects.

An Interpretation of a Geometrical Problem Posited by Anthemius of Tralles¹²⁷

It can often be observed that the central area of many Byzantine church domes appears constantly radiant. The light seems to emanate from the representation of Christ Pantocrator that usually occupies this position (Fig. 5.). In some churches this radiance of the dome can be observed today and is emphasized by the shape of the pendentives that are also lit and thus appear to dynamically lift the dome off the ground (Fig. 5.). This effect is particularly powerful when the remaining surfaces of the church are somewhat darker and it might be thought to assume a specific religious meaning. The Pantocrator

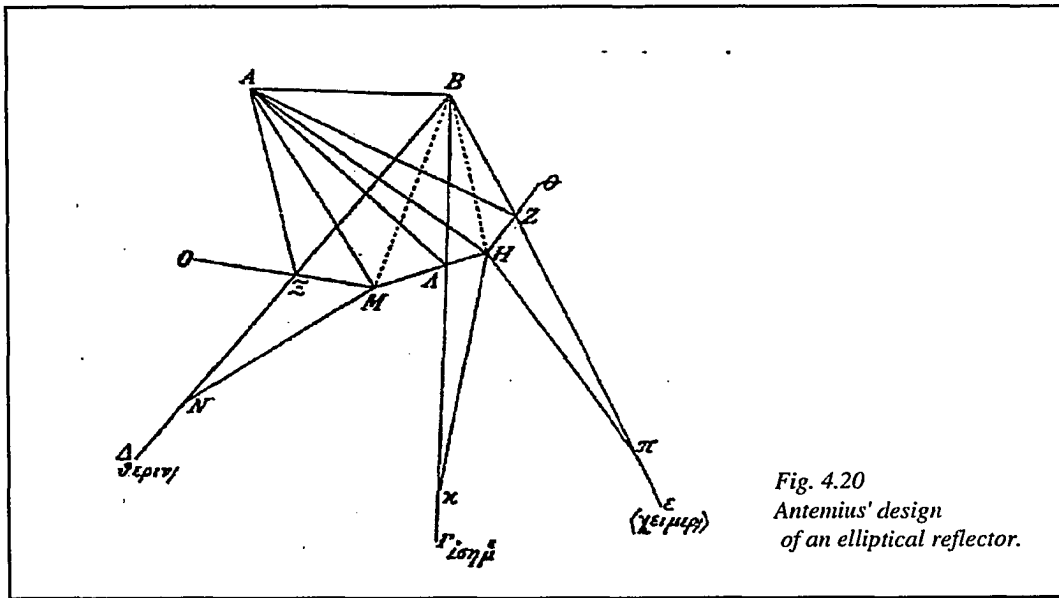


Fig. 4.20
Anthemius' design
of an elliptical reflector.

(Ruler of All), as the sole distributor of “true light” to the world, is not lit directly by sunlight but is made to appear to emit constant, “uncreated light” (aktiston fos) emanating from within Him.

The generation of such an impression, however, would not occur naturally and automatically in any domed church, but would require creating especially designed contrivances and coordinating the effects produced by various architectural elements, such as manipulating the configuration of the dome windows and window sills and perhaps - the curvature of the dome as well. The desire to achieve these special effects seems to have propelled Anthemius's interest in devising a particular reflector (Fig. 4.20),¹²⁸ as this is precisely the effect that such a reflector would have achieved had it been installed at the window sills of the dome of Hagia Sophia of Istanbul (Fig. 4.21).¹²⁹

This problem is discussed in Anthemius' essay entitled “Peri Paradoxwn Mhcanhmatwn” (About Paradoxical Machines),¹³⁰ reproduced in a monograph by G. L. Huxley; the essay appears in the original Greek text with an English translation and commentary.¹³¹ The problem concerns the construction of a reflector capable of constantly directing sunrays at a single point within a building, taking into account the

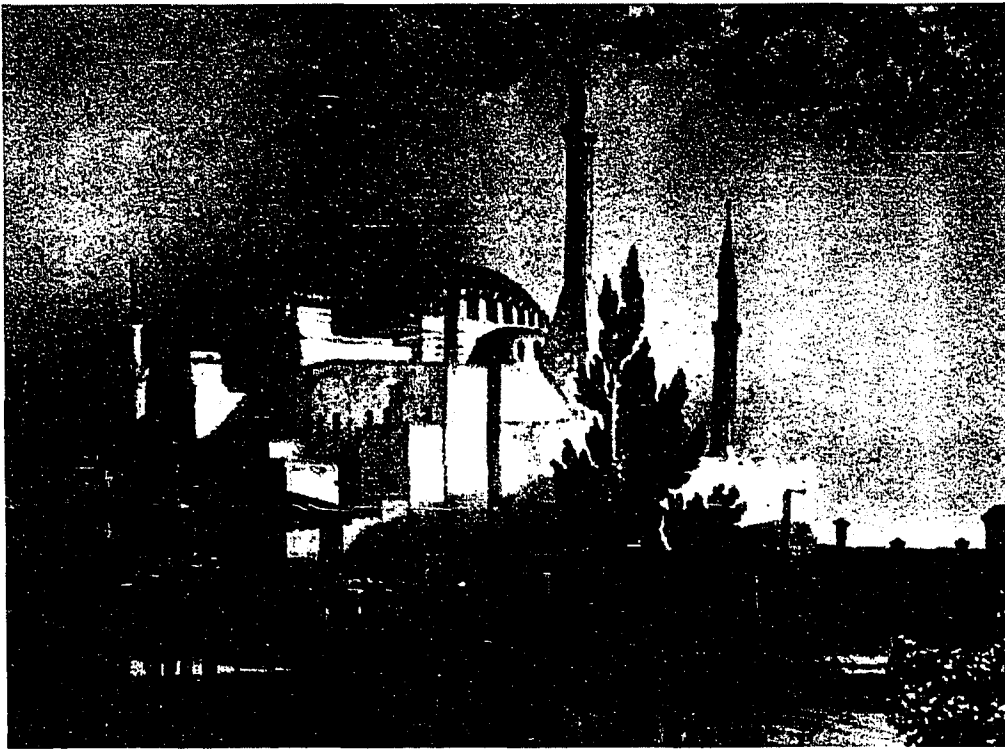


Fig. 4.21 H. Sophia, Istanbul

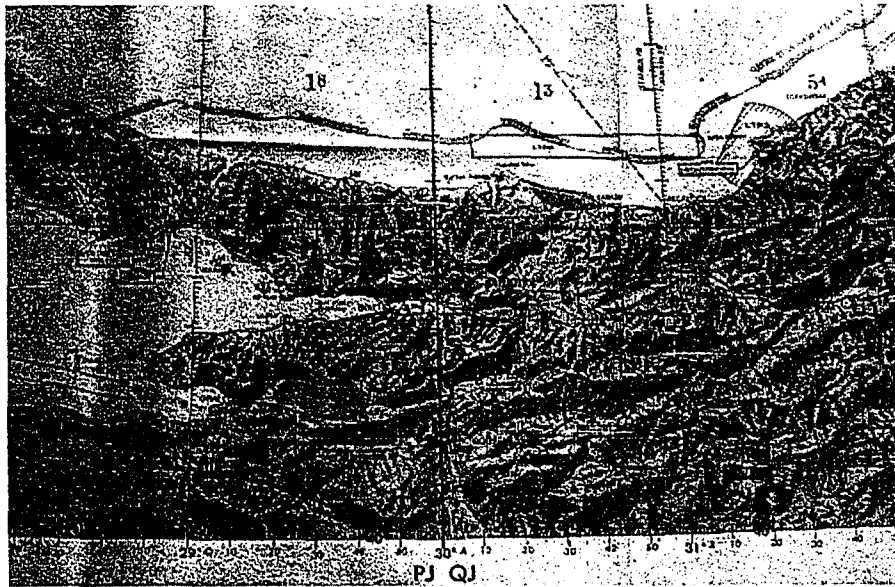
varying positions of the sun throughout the day and the seasons (Fig. 4.20). Agathias' and Huxley's interpretation that this mirror was used as a practical joke against the orator Zeno is inappropriate, considering its properties in respect to light reflectance.¹³² The reflector is described by Anthemius as being stationary and securely fastened onto a permanent structure and so designed as to produce a long term effect.¹³³ But even if Anthemius did use some of the inventions described in his extant writings in the way suggested by Agathias, this would provide evidence of Anthemius' extraordinary facility in inventing sophisticated mechanical contrivances for directing light at will. Therefore, it would come natural to him to design such devices if he thought them appropriate and important to Hagia Sophia, his life masterpiece.

These writings by Anthemius are often collectively referred to as his studies on the burning mirrors or burning glass. The particular problem under examination, however, does not pertain to a focusing reflector. The intention here is not to cause burning,

but simply to direct the rays of the sun to a given point.¹³⁴ The geometry of the ellipse, which is here examined, is derived for the express purpose of directing without focusing, the rays of the sun to a single point during the course of the day and year. Moreover, Anthemius directly relates this to the summer and winter solstices and to the equinox and mentions an opening through which the rays would have to pass before reaching the elliptical reflector.¹³⁵ Hence, he refers to a building within which a certain stationary point¹³⁶ is to be constantly illuminated, regardless of the position of the sun in the sky. (Fig. 4.20). A statement of this sort could very well pertain to the illumination of the dome of Hagia Sophia, which would necessitate precisely such a solution for the achievement of a constant radiance in the central part of the dome.

It is clear, to any mathematician, that the form of such a reflector is independent of latitude and of the direction which the light comes from as long as the light penetrates through the prescribed opening.¹³⁷ Therefore, the fact that Anthemius relates it to summer and winter solstice and the equinox is redundant. This clearly indicates that Anthemius was not interested in resolving the problem in its most general theoretical form, as a pure mathematician would have done. Rather, he was interested in resolving it as a case study incorporating the exact circumstances peculiar to the problem.¹³⁸

These specific circumstances are indicated by the azimuth angles chosen in the accompanying diagram¹³⁹ in Anthemius' excerpt.¹⁴⁰ The selection of azimuth angles appears to be very closely related to factors of topography peculiar to Istanbul (Fig. 4.22), as these affect the points at which the sun becomes visible at sunrise. Moreover, it appears that the measurements of the azimuth angles had been taken from a point in the city of Istanbul where the summer solstitial sunrise would be visible as low in the horizon as possible while the equinoctial and winter solstitial sunrise would be uniformly higher. This would tend to be true as one moved closer to the eastern edge of the city where there would be no obstruction to the NE while there would be a mountain range to E and SE. And this is the area of the city where Hagia Sophia is located (Fig. 4.23).¹⁴¹ In addition,



*Fig. 4.22 Operational Navigational Map of Istanbul and Asia Minor
(U.S Defense Mapping Agency)*

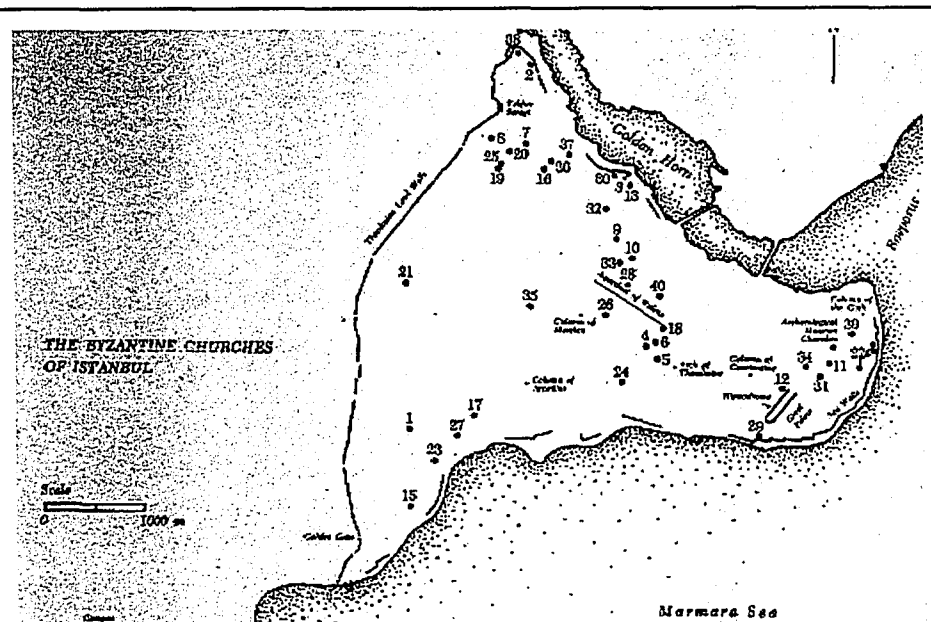


Fig. 4.23 Area of H. Sophia location, Map of Istanbul

Anthemius speaks of a hole placed symmetrically about (Fig. 4.20) a center, and the rays falling through the hole, upon the mirror, which means that the mirror would be placed below the hole or window opening, that is, on the window sill.

The above observations indicate that this clearly is not a statement of an abstract theoretical geometrical problem and its method of resolution does not indicate an interest in the properties of the ellipse as a pure geometrical form but in its capacity to reflect the rays of the sun in a specific way for a concrete application related to an actual building.

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The clear expression and resolution of the problem plainly demonstrates that Anthemius was capable of generating shapes of reflectors that could direct the rays of the sun at will and as the situation required. This knowledge does not seem to have been something unusual for an architect. Alan Cameron and Toomer argue that Anthemius' geometrical demonstrations probably reflect the more practically oriented training of an architect because they appear rather clumsy for a mathematician.¹⁴³ Nonetheless, for Anthemius, it was possible to handle light with great specificity and precision, and to conceive of its manipulation as an integral geometrical problem conceived as part as surely and as concretely as that of the built form. Light could be directed and focused dictating not only the shapes of reflectors but also of major formal elements.¹⁴⁴ In this respect light could become, in fact, a generative force in the church geometry.

Since light was conceived of, both theologically and aesthetically, as being expressive of the essence of God it would have seemed most appropriate to devise a geometry based on shapes capable of exploiting natural light for the enhancement of particular images and religious experiences. Given the fact that the effect of a glowing Pantocrator may be observed in many Byzantine churches it appears almost certain that this is a problem statement that aims at the invention and construction of a reflector capable of attaining this unique effect. This is not to say that Byzantine churches generally employed such sophisticated devices. But this case represents the most perfected solution

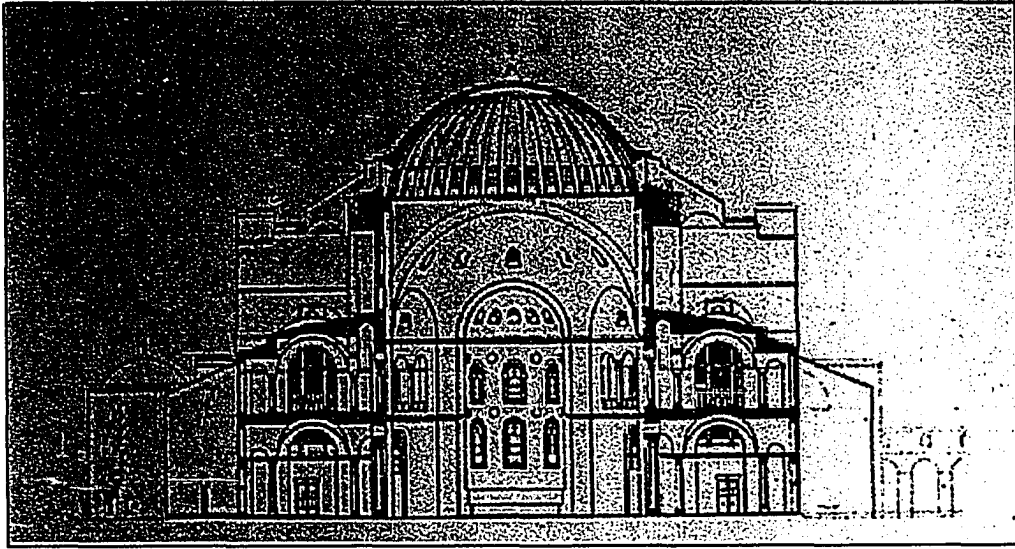


Fig. 4.24 Transverse Section H. Sophia, Istanbul according to Antoniadès and Schneider

conceivable as compared to other possible solutions that would provide a similar but less effective image. Anthemius states:

It is required to cause a ray of the sun to fall in a given position, without moving away, at any hour or season.¹⁴⁵

It appears that Anthemius was faced with the practical task of constructing a mirror with these particular properties. However, by reverting to the particular methods he employed, to solve the problem, Anthemius seems to have confronted certain constructional difficulties and limitations. The reflector, in order to satisfy the conditions posed by the problem statement, would have to be elliptical in three dimensions. By the way it is described, this reflector would have had to adapt to a situation which was not yet known¹⁴⁶ - that is, the relationship and distance between the point of entry of light and the point to which it would be reflected. Instead of using the simplest and most direct method of a rope attached to the two foci of an ellipse, Anthemius followed quite a difficult process for constructing the reflector by means of tangents. This process requires the direction of the sun's ray, the position of the central point of the opening, the distance

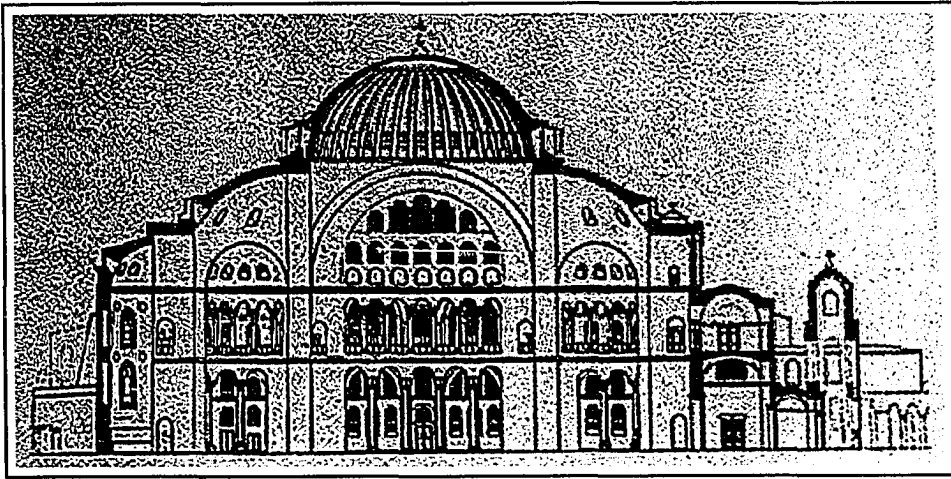


Fig. 4.25 Longitudinal Section of H. Sophia, Istanbul according to Antoniadès and Schneider

from the point of destination (the center of the dome), which can be calculated indirectly, and the direction of a line pointing at the point of destination. Then, simply by bisecting the angles between the main directions of the sun's rays (equinoctial, summer, winter solstitial) at their meeting point, at the center of the opening, he determines the length of plane mirrors. The only advantage of this method is that it does not require that a rope be attached at the point of destination A. This method suggests that there might have been some difficulty anticipated in accessing this point or that it might have been thought unwise to attach a rope at it. Such fears would have been only natural considering the unusual techniques and precarious shapes that were to be or had been employed in the construction of the dome of Hagia Sophia. And its designer would have been reluctant to disturb its structural coherence if he could avoid it. Only at the end of his problem solution does Anthemius refer to the simplest and most common way of constructing an ellipse by way of attaching a rope at both the point of destination, A, and the center of the opening, B, which enables one to keep the sum of the distances from these two foci constant. Anthemius refers to this only as a method for refining the surface of the reflector.

So if this problem was posed and resolved, in fact, for the purpose of illuminating indirectly the dome of Hagia Sophia with a constant light throughout the day and the seasons, then the individual reflectors of the type described by Anthemius should have been situated on the window sills of each dome window. Anthemius's diagram (Fig. 4.20) indicates that the sun rays would be reflected toward the point of destination, A, the highest point of the dome from the interior, after they penetrated through the center of the opening, B, and not before.¹⁴⁷

It appears that Procopius' written account of the church (which generally places great emphasis on light¹⁴⁸) is in agreement with the hypothesis proposed here.

Upon the crowns of the arches rests a circular structure, cylindrical (spherical?) in shape; it is through this that the light of day always first smiles. For it towers above the whole earth, as I believe, and the structure is interrupted at short intervals, openings having been left intentionally, in the spaces where the perforation of the stone-work takes place, to be channels for the admission of light in sufficient measure.¹⁴⁹

It is important to note some subtle meaning variations of the Greek words of the original text that are not translated accurately in the Loeb edition of Procopius. The part of the sentence "feggouV diarkwV agwgouV einai" is translated as "to be channels for the admission of light in sufficient measure." The word "feggoV" does not mean "light" (which would be "fwV"¹⁵⁰) but rather "gleam," or "glimmer." The word "diarkwV" does not mean "in sufficient measure" (which would be "eparkwV") but rather "incessantly," or "continuously." Finally the word "agwgoV" can be rendered as "channel" but has a meaning that comes closer to a "conductor" or "pipe."¹⁵¹ So, the meaning changes considerably when this part of the sentence is translated as "to be conductors of an incessant gleam." This rendering of the sentence denotes deep, rather curved window reveals and mostly reflected light, rather than direct, coming through the windows. Also, it is incessant and of a probably warm tinge (Fig. 4.26).

Now, if these elliptical reflectors continued up on the window reveals on both sides of the window, then the effect of a radiant dome would have remained constant

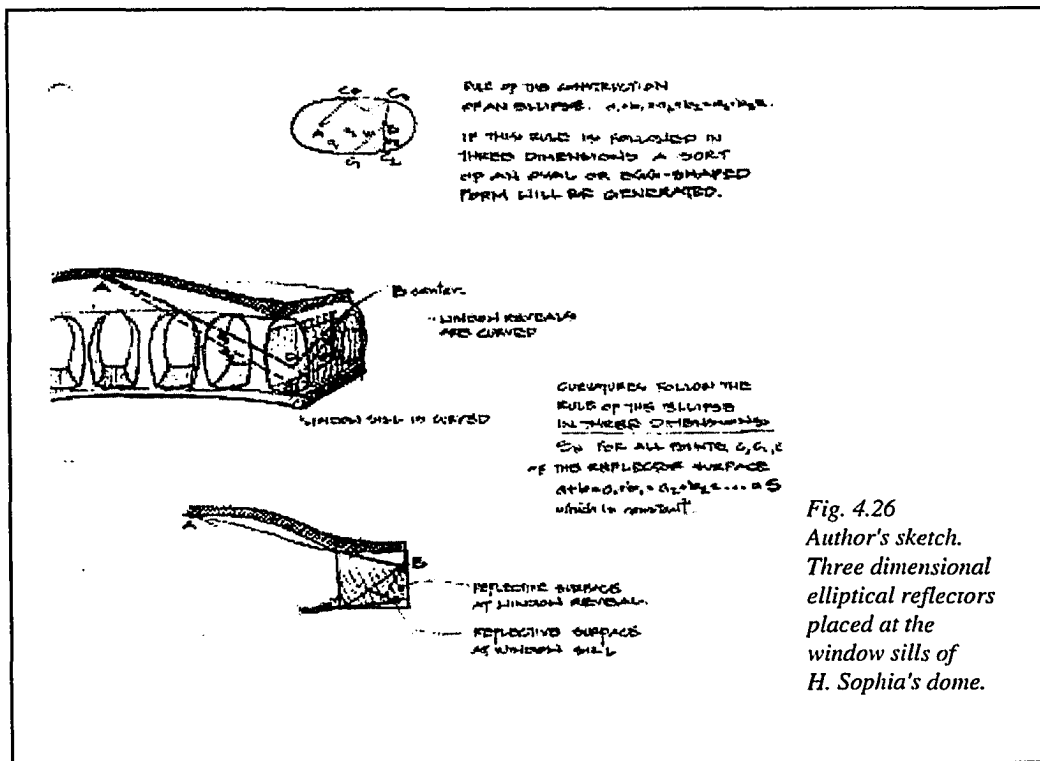


Fig. 4.26
Author's sketch.
Three dimensional
elliptical reflectors
placed at the
window sills of
H. Sophia's dome.

throughout the day commencing at sunrise and lasting until the sunset. Moreover, the reflectors placed on the window reveals would allow reflected light to shine upon the central part of the dome through windows with more northerly orientation as well, although no direct light could have penetrated through them (Fig. 4.26). In this way the central spot of the dome would have acquired a well balanced brilliance.

Procopius mentions that the first light of day was captured by the dome and that he thought that this had been intentionally designed.¹⁵² So this “oven shaped reflector,”¹⁵³ (or “funnel” which is the name given to it by Anthemius) should be constructed with A, B as the foci and the upper limits of the three-dimensional surface that would be produced would be determined by the azimuth and the altitude of the sun at sunrise and at sunset (Fig. 4.26). Such a reflector would have made the dome windows look like tubes, which comes much closer to the meaning conveyed by the word “conductor” which is used by Procopius.

This intense light received from the window sills and reveals and subsequently reflected off the dome's own mosaic would have immensely intensified the hovering effect by creating some kind of a cloud of light, or atmospheric effect making the material dome appear more distant and therefore as disconnected from the building. This would be even more intensified by the fact that the specular surfaces of golden, glazed mosaic surrounding all window reveals and window sills would create a bleeding effect on the window sides so that the distance between the windows would be perceptually diminished disconnecting, in this way, the dome from its base.

The form of the dome windows, as reconstructed above, would create a situation which would satisfy all three descriptions by Procopius. First, the description of the dome windows as being "conductors of an incessant gleam," ¹⁵⁴ second that it is "through (the dome) that the light of day always first smiles," ¹⁵⁵ and third that the dome "does not appear to rest upon a solid foundation, but to cover the place beneath as though it were suspended from heaven by the fabled golden chain." ¹⁵⁶

These reflectors could have been constructed by golden, glazed mosaic carefully laid out on a preset mortar base. ¹⁵⁷ Careful setting and angling of mosaic tessellae in order to direct reflected light is reported by modern scholars at least in two cases in Hagia Sophia. ¹⁵⁸ It would not have necessarily required a perfectly constructed reflector with a single, uniform surface although such reflectors was possible to be constructed in antiquity. ¹⁵⁹ That this was the method of physical construction of these reflectors is implied also by the method employed in the theoretical solution of the problem where flat mirrors are subdivided into ever smaller parts until they acquire at last the nearest possible approximation to an ellipse. Flat mirrors are also employed in subsequent problems resolved by Anthemius. ¹⁶⁰

By installing the type of reflectors described above, virtually any dome (at least the central part of it) could be brightly, evenly, and constantly lit. However, it is known that the original form of the dome of Hagia Sophia was of a very peculiar and unusual

shape, one that made it structually vulnerable- a fact which was already recognized at the time of its construction. In the next chapter an analysis of this original dome will be presented in relation to the manipulation of light and the reflector discussed above.

Notes to Chapter IV

¹ The "Passage Graves" of Ireland (3300 B.C.) were astronomically aligned. For instance, the main axis of the tomb at Newgrange is oriented toward sunrise on the winter solstice. This date and time of the year would have been important for members of the farming community, as they could begin to expect longer and warmer days. At Newgrange a stone formed a capstone to a slit in the roof of the tomb, a sort of a "roof box", which today allows the sun to shine into the tomb at the winter solstice. The grave at Knowth is oriented toward the equinox. Other "passage graves" have different orientations possibly in alignment with planets or stars. See George Eogan, Knowth and the Passage Tombs of Ireland, (London: Thames and Hudson, 1986): 183, 182.

² Many of the Megalithic Monuments of Britain and France (1500 B.C.), contain indicators showing rising or setting points of the sun at the solstices. Other equally spaced dates throughout the year are also indicated. The moon was carefully observed as well as the first-magnitude stars. See Alexander Thom and Alexander S. Thom, Megalithic Remains in Britain and Brittany, (Oxford: Clarendon Press, 1978): vi, also A. Thom, Megalithic Sites in Britain (Oxford: Clarendon Press, 1967):1, also G.S. Hawkins, "Stonehenge Decoded," Nature, London 200, 306 (1963) and "Stonehenge: A Neolithic Computer," Nature, London 202, 1258 (1964), also John N. Lockyer, Stonehenge and Other British Stone Monuments (Macmillan, 1909), also S. Piggott, "Architecture and Ritual in Megalithic Monuments," Journal of Royal Institute of British Architects, (Ser.3) 63, 175 (1956), also A. Thom, "The Solar Observatories of Megalithic Man," Journal of British Astronomical Association, 64, 397 (1954).

³ The Egyptian Temples and Pyramids are reknown for their precise alignments with heavenly bodies. The great pyramid of Khufu at Giza as well as the smaller ones nearby are oriented to true east. The accuracy of the orientation is impressive, considering the methods available in the fifth millenium B.C. See Petrie, Pyramids and Temples of Gizeh : 39, 97, 111. The alignments were achieved through empirical observation by means of a process of stretching lines on a level desert from a stake in the directions of sunrise and sunset preferrably toward the time of the solstices, when the declination changes most slowly, so that a line bisecting the angle thus formed yields a true north-and-south line, and one at right angles a true east-and-west line. See Cole, Determination of the Exact Size and Orientation of the great Pyramid of Giza, Survey of Egypt Paper No.39, (Cairo, 1925): 8, also Borchardt, Längen und Richtungen der vier Grundkanten der grossen Pyramide bei Gise (Berlin, 1926): 3, 8. For more information see Kenneth Heuer, City of Stargazers (New York: C. Scribner's Sons, 1972), also Lockyer, The Dawn of Astronomy. A Study of the Temple Worship and Mythology of the Ancient Egyptians (London: Cassell and Company Lim., 1894), also Nissen, Rheinisches Museum fur Philologie (1885), also C. F. Dupuis, The Origin of All Religious Worship (New York: Garland Publishing, Inc., 1984), also Kim Levin, "The Eye of Ra," in Light in Art T.B. Hess and J. Ashbery eds.: 22-36, also Jean L. de Cenival, Living Architecture: Egyptian (New York: Grosset & Dunlap, Inc., 1964), also Jon K. van der Haagen, "Rameses' Mysterious Encounter at Dawn," UNESCO Courier, Oct. 1962), also G. Legrain, "Observation d'un Phenomene Optique," Annales du Service des antiquites de l'Egypte, v.16, (1916). Sun-worship was prevalent among the Egyptians. Of great religious importance to them were the so-called "star clocks." Eighty-one monuments are known to have some astronomical content. Most of these are tomb and temple ceilings. The earliest known astronomical ceiling is in the Tomb of Senmut (1473 B.C.), the

architect of Queen Hatshepsut's mortuary temple at Deir-el-Bahri. This ceiling contains a star-clock with representations of planets. Edwin C. Krupp, In Search of Ancient Astronomies (New York: McGraw-Hill Co., 1979): 205, 8, 9, 14.

⁴ Anthony Aveni, "The Thom Paradigm in the Americas: The Case of the Cross-Circle Designs," in Charles L. N. Ruggles, Records in Stone: Papers in Memory of Alexander Thom (Cambridge: Cambridge University Press, 1988): 442-472.

⁵ Eleanor Manikka Moron, "Kambodian Temples", Science v. 24 (July 1974).

⁶ Part of this chapter was presented as an invited paper at the Third Meeting of the International Society for the Classical tradition at Boston University on March 10th, 1995 with the title "Transition in the Use of Natural Light from the Ancient Greek Temple to the Byzantine Church: Apt Evolution or Conscious Revolution?"

⁷ F.C. Penrose, "On the Orientation of Certain Greek Temples and the Dates of their Foundation," Proceedings of the Royal Society, 53, 61, 65, 68 (1893-1901), and Transactions of the Royal Society, 184, 190, 196 (1893-1901), and "The Orientation of Greek Temples," Nature v.49 (London, May 11, 1893): 42-3. Also see Lockyer, The Dawn of Astronomy, (1894) Reprint Edition (Cambridge, MA: MIT Press, 1973). In particular about the orientation of the Parthenon : 416.

⁸ Penrose, Nature v.48, no.1228 (May 11th 1893): 42.

⁹ He calculated these dates based on the astronomical phenomenon of the Precession of the Equinoxes. See Penrose, "On the Results of an Examination of the Orientations of a Number of Greek Temples . . .," Philosophical Transactions of the Royal Society of London v. 184 (1894): 805-34.

¹⁰ William B. Dinsmoor "Archaeology and Astronomy," Proceedings of the American Philosophical Society, 80 (1939): 95-173.

¹¹ Vincent Scully, The Earth, The Temple, and The Gods: Greek Sacred Architecture (New Haven: Yale University Press, 1979): 121,

¹² Dinsmoor "Archaeology and Astronomy": 119-123.

¹³ *Ibid.*: 123-173. "The axes of Greek temples box the entire compass; but more than 80% run, if not exactly east-and-west, at least within the arc formed on the horizon between the sunrise directions at the summer and winter solstices. It seems that most temples were laid out to face the sunrise on the actual day of their foundation, presumably the festival day of the divinity; a minority faced in other directions for special reasons of site, tradition, or relation to other buildings." See Dinsmoor, The Architecture of Ancient Greece (New York: W.W. Norton and Company, 1975) :49.

¹⁴ See chapter 3.

¹⁵ Dinsmoor, Architecture of Ancient Greece: 49.

¹⁶ Aeschylus, Agamemnon: 519-520 cited in Dinsmoor, The Architecture of Ancient Greece: 49 note 1

¹⁷ *Ibid.* 393

¹⁸ Such as the temples of Zeus Olympius at Acragas, Heraeum at Samos, Later Temple of Apollo at Didyma near Miletus, temple of Zeus Olympius at Athens, etc. Ibid.: 106; a lantern or opaion was employed at the hypostyle hall at Delos the roof of which projected above the main roof Ibid.:295; a lantern or opaion was also used in the design of the Telesterion at Eleusis Ibid.: 196; the Croesus Temple at Ephesus may have been largely open to the sky Ibid.: 128; the Temple of Apollo at Didyma was hypaethral Ibid.: 229; the Olympieum at Athens may have been hypaethral Ibid.: 281.

¹⁹ Ibid: 151, Note 3.

²⁰ Referring to the Temple of Zeus at Olympia (c. 460 B.C.) one of the largest Doric temples erected in Greece, Dinsmoor notes: "Pausanias speaks particularly of the roof of Pentelic marble "wrought into the shape of tiles". It has been suggested that Parian marble was employed for tiles on account of its translucency, which would not only light the space between the roof and the ceilings of the peristyle and cella, but might even partly account for the illumination of the interior of the cella, through openings in the framed ceiling, which otherwise was lighted alone through the open door. But the existence of special tiles with elliptical openings shows that the architect was not disposed to rely solely on the translucency of the material." Ibid.: 151, Note 3.

²¹ Such as in the Temple of Olympia, Dinsmoor, Ibid.: 106. Also in temples at Athens, Calydon (Heroum), Olynthus, Corinth, Tegea, Bassae, Colophon, Priene, and in Italy at Caulonia, Sybaris, and Pompeii. Ibid.: 151, 219.

²² Ibid.: 151 note 3, 159

²³ Flourished around 190-180 B.C. See G.J. Toomer, Diocles on Burning Mirrors. The Arabic Translation of the Lost Greek Original ed. with English transl. and commentary by Toomer (New York:Springer-Verlag, 1976): 2

²⁴ ". . . an ingenious method has been found for a burning-mirror to burn without being turned to face the sun; instead it is fixed in one and the same position, and indicates the hours of the day without a gnomon. It does this by burning a trace to which the rays are reflected: the reflecting produces a trace for the position of the hour which is sought. This statement is amazing, namely that there is no need to turn the mirror, but that (what we have described) results merely from the above-mentioned figure." Ibid.: 38.

²⁵ Ibid.: 44. Toomer, in his commentary, suspects that this is an interpolation in the Arabic translation. Toomer suggests that the use of glass lamps seems characteristic of Byzantine times and Christian churches Ibid.: 149. Toomer does not see anything specifically un-Greek in this statement, however, he only questions the position of the passage if this refers to a lens, and he believes that this positioning would not be logical for Diocles to discuss it here. If, however, this passage refers to Byzantine times and Christian churches as Toomer suggests, I do not see how would the generation of fire and the burning of sacrificial victims could be of any use to Christians or Muslims to want to imitate it. Diocles seems to be speaking of either a burning-glass or a glass-mirror. The burning-glass or lens referred to as "hyalos" was known since at least the 5th century B.C. Aristophanes (448-385 B.C.), *Clouds* :768 quoted by Mary Luella Trowbridge, "Philological Studies in Ancient Glass," in University of Illinois Studies in Language and Literature V. XIII, No.3-4 (August-November, 1928): 178-9. References to glass-mirrors are made in Theophrastus (372-287 B.C.), Plato (427-347 B.C.), Pliny (A.D.23-79) and Pausanias (flourished A.D. 175) but the first genuine glass mirror is described by Alexander of Aphrodisias (A.D. 220). (in Pliny quoted in Trowbridge:184-5.) However, a mirror able to kindle a fire could only be curved. Such a mirror, according

to Diocles, would be constructed of brass. (Toomer, Diocles: 48), which could be hammered to a desired shape and polished to a high shine or perhaps of arsenical copper which was used to plate metal objects (See commentary of Toomer Ibid.: 152-3), also see Forbes, Ancient Technology VIII :272-86 and Caley, Orichalcum Chs. III, VIII.

²⁶ According to G. Downey, Heron lived between 150 B.C. and A.D. 250 “Pappus of Alexandria on Architectural Studies,” Isis, vol. 38, (1948): 198, note 4; Heath places him in the 3rd century A.D. Heath History of Greek Mathematics v.2: 306-7; while Neugebauer claims that Heron’s date can be securely fixed in the 1st century AD. See, Neugebauer, A History of Ancient Mathematical Astronomy v.2: 846.

²⁷ Toomer, Diocles: 149. Heron is considered to be as eminently practical. Alan Cameron, “Isidore of Miletus and Hypatia: On the Editing of Mathematical Texts,” Greek, Roman, and Byzantine Studies, v. 31 (Spring 1990): 120. Also Heath History of Greek Mathematics v.2 : 307.

²⁸ Wilhelm Schmidt, Heronis Alexandrini Opera Quae Supersunt Omnia Pneumatica et Automata (Leipzig: Druck und Verlag von B.G. Teubner, 1899) vol. I, Part 1, Proposition XII: 80-4.

²⁹ Ibid. vol. I, Part 2, Proposition XXI: 262-5.

³⁰ Ibid. vol. I, Part 1, Proposition XVII: 98-100.

³¹ Ibid. vol. I, Part 1, Proposition XXXII: 148-151.

³² Schmidt, vol. I, Proposition XXXVIII, XXXIX: 174-183.

³³ Wilhelm Schmidt, Heronis Alexandrini Opera Quae Supersunt Omnia Mechanica et Catoptrica (Leipzig: Druck und Verlag von B.G. Teubner, 1900) vol. II, Proposition XII: 342-5 and Fig. 85 a, b, c.

³⁴ Ibid. vol. II, Proposition XV: 350-3 and Fig. 88 a, b.

³⁵ Ibid. vol. II, Proposition XVI: 352-7 and Fig. 89.

³⁶ Ibid. vol. II, Part 1, XVIII: 358-65 and Fig. 91a, b.

³⁷ Heath, History of Greek Mathematics, v. 2 :352-354. See W. Schmidt, ed., Heronis Opera vol.ii.

³⁸ Vitruvius, De Architectura, transl. M.H. Morgan (New York: Dover Publ. 1960), 4, 5, 1.

³⁹ Ibid.:4, 9.

⁴⁰ A “roofed spherical dial” is a concave sundial with a hole pierced on its roof through which a ray enters and generates a spot of sunlight which indicates the time. See chapter 3.

⁴¹ See J.N. Lockyer, The Dawn of Astronomy. A Study of the Temple Worship and Mythology of the Ancient Egyptians (London:Cassell and Company Lim., 1894):95-6; also George Gilbert Scott, An Essay on the History of English Church Architecture (London:Simpkin, Marshall and Co., M:DCCCC:LXXXI):14; also H.W.

Brewer, "Old St Peter's, Rome," The Builder (Jan. 2, 1892):4.

⁴² Michelis, An Aesthetic Approach to Byzantine Art : 39-40. See also chapter 5.

⁴³ The dome of the cross-shaped mausoleum of Galla Placidia is decorated with a mosaic of a great cross placed on a deep blue sky, dotted with golden stars. In St. Vitale in Ravenna on the top of the vault of the Bema the Savior as lamb is depicted within the round star-dotted glory supported by four angels, whose bodies create a cross. See the examples of the mosaic of the Julius tomb in the Vatican Necropolis (third century) The mosaic in the quarter-sphere of the Bema of the Mone Latomou in Thessaloniki. The mosaic of Lord's Glory (5th century) displays Christ in the same manner placed within a round glory and sitting on a rainbow. Similarly in the quarter-dome of the St. Vitale apse Christ is represented in Paradise as beardless, "shining youth," sitting on the globe of the world surrounded by two angels. Below, in both sides of the arch the earthly kingdom is represented with Justinian on the north side and Theodora on the south side among court personages.

⁴⁴ See Part 2 and chapters 2.

⁴⁵ See chapters 4, 5.

⁴⁶ The theological and aesthetic conceptualizations of the divine which led to the Gothic designs had their sources in Byzantine theological writings. See chapter 2. For information about the Cistercian monasteries see Wolfgang Braunsfels, Monasteries of Western Europe (Princeton: Princeton University press, 1980):208, 245. The most relevant effects employed in the Baroque are found in the churches of Bernini, Borromini, and Guarini. For 19th c. churches see Lockyer, The Dawn of Astronomy. A Study of the Temple Worship and Mythology of the Ancient Egyptians (London: Cassell and Company Lim., 1894):95-98; also Builder (Jan. 2, 1892) and George Gilbert Scott Essay on Church Architecture.

⁴⁷ Built around 350-330 B.C.

⁴⁸ Vitruvius, De Architectura transl. by M.H. Morgan (New York:Dover Publications, 1960),7, Introduction, 12 and 13.

⁴⁹ Ibid.: 1, 1, 12

⁵⁰ Ibid.: 1, 1, 3.

⁵¹ Heath The History of Greek Mathematics vol. 2 : 223, also Neugebauer, A History of Ancient Mathematical Astronomy, v.2: 893.

⁵² Ibid.: v.2: 293.

⁵³ Ibid.: vol.1: 17-18, vol.2:223

⁵⁴ Ibid.: 17-18

⁵⁵ Neugebauer, A History of Ancient Mathematical Astronomy, v.2: 966.

⁵⁶ Vitruvius, De Architectura 1, 1, 1 and 2.

⁵⁷ According to Downey, Heron lived between 150 B.C. and A.D. 250. Glanville Downey, "Pappus of Alexandria on Architectural Studies," Isis, vol. 38, (1948): 198, note 4.

⁵⁸ Ibid: 197-200. For dates of scientists mentioned see also Neugebauer, A History of Ancient Mathematical Astronomy, v.2:893.

⁵⁹ Richard Krautheimer and Slobodan Curcic, Early Christian and Byzantine Architecture in Pelican History of Art Series 4th ed. (New Haven:Yale University Press, 1986): 206.

⁶⁰ Anthemius is called "mêchanopoios" by Procopius De Aedificiis 1,1,50 and by Agathias (536-582 A.D.) Historiae 5, 8 (Bonn ed.):293. Anthemius once is called "the most learned man in the skilled profession known as mêchanikê." Procopius, De Aedificiis, 1, 1, 24, 71, 76; 2, III, II. Isidorus is given the title mêchanikos in an inscription of Chalkis sub Belo in Syria dated A.D. 550 which records the rebuilding of the city walls under his supervision: L. Jalabert and R. Mouterde, Inscriptions Grecques et Latines de la Syrie (Paris, 1929), No. 348.

⁶¹ Downey documents his argument by a careful textual analysis of certain literary documents, the main one being Pappus' of Alexandria Collection written at about A.D. 320. Downey "Pappus of Alexandria on Architectural Studies," :197-200; and "Byzantine Architects, their Training and Methods," Byzantion vol.18, (1946-8): 99-118. Also see Ivor Thomas, Selections Illustrating the History of Greek Mathematics (1939-1941), 2: 564 note a. "The mechanicians of Heron's school say that mechanics can be divided into a theoretical and a manual part; the theoretical part is composed of geometry, arithmetic, astronomy, and physics, the manual of work in metals, construction work, carpentering, and the art of painting and the manual execution of these things. The man who has been trained from his youth in the aforesaid sciences as well as practised in the aforesaid arts, and in addition has a versatile mind, will be, they say, the best builder and inventor of mechanical devices." On this Downey comments: "Today astronomy is not a major part of the curriculum (of architectural training), but in antiquity it was. Witness Vitruvius emphasis on astronomical knowledge for the orientation of buildings and such matters." Downey, "Pappus" :198 and note 8. For a complete translation of Pappus' text see Ivor Thomas, Selections Illustrating the History of Greek Mathematics (1939-1941): 615-617.

⁶² Downey, "Pappus of Alexandria on Architectural Studies," : 198, note 4, 200 and note 15. Also Heath, The History of Greek Mathematics v.2: 306-7. Also J. L. Heiberg, Science and Mathematics in Classical Antiquity (London:Oxford Univ. Press,1922).

⁶³ Downey, "Byzantine Architects. Their Training and Methods": 110.

⁶⁴ Procopius De Aedificiis 1, 1, 24.

⁶⁵ Agathias, Historiae, 5. 8. 3 (p. 171.7 Keydell).

⁶⁶ Alan Cameron "Isidore of Miletus and Hypatia: On the Editing of Mathematical Texts," Greek, Roman, and Byzantine Studies, v. 31 (Spring 1990): 122

⁶⁷ Vitruvius, De Architectura 1, 1, 16

⁶⁸ Ibid. 1, 3, 1.

⁶⁹ Heath, The History of Greek Mathematics v.2 : 307

⁷⁰ See a discussion of the term “mechanician” or “mêchanikos” later in this chapter. Also see Heath, The History of Greek Mathematics v. 2 :306-307.

⁷¹ Ibid. :306

⁷² Cameron, “Isidore of Miletus and Hypatia: On the Editing of Mathematical Texts,”: 120.

⁷³ Heath, The History of Greek Mathematics v. 2 : 307-8.

⁷⁴ Cameron, “Isidore of Miletus and Hypatia: On the Editing of Mathematical Texts”: 121

⁷⁵ Ibid.:122-3.

⁷⁶ Vitruvius, De Architectura 1, 1, 4.

⁷⁷ Ibid. 1, 1, 10.

⁷⁸ Ibid. 9, 8.

⁷⁹ Vitruvius deals with these collectively in his ninth book and devotes the entire book to them.

⁸⁰ J.L. Heiberg, Science and Mathematics in Classical Antiquity, transl. D.C. Macgregor, ed. C.Singer (London:Oxford University Press, 1922): 88-9.

⁸¹ Ibid.: 91.

⁸² Wrote a commentary on Euclid’s *Elements*.

⁸³ Wrote a commentary on an *Introduction to Arithmetic* by Nicomachus.

⁸⁴ Neugebauer, A History of Mathematical Astronomy, v.2:1031.

⁸⁵ He was pupil of Olympiodorus of Alexandria and Syrianus and became the latter’s intimate friend and successor in the directorship of the Neoplatonic Academy in Athens. Ibid. v.2: 1031. Also see, J. F. Boissonade, Proclus, Opera Inedita (Paris, 1864): 1-66. He was taught the Neo-Platonic philosophy in Athens. A philosopher, a mathematician, and a poet, Proclus was a believer of all sorts of myths and mysteries and a worshipper of divinities both Greek and Oriental. See Heath, The History of Greek Mathematics v. 2 : 530. Proclus, wrote a commentary on Book I of the *Elements* of Euclid, which, in spite of a lot of mysticism and symbolism, contains much valuable historical information, mainly drawn from Geminus’ See Heiberg, Science and Mathematics in Classical Antiquity: 95. See Heath, The History of Greek Mathematics v. 2 : 531. Also, about Geminus and his “Isagoge” see Manitius, Geminus, Introduction: 23-25. Proclus believed that the development of Euclid’s *Elements* had an astronomical basis. See Neugebauer, A History of Mathematical Astronomy, v.2: 1034-5. Proclus also wrote a book called Hypotyposis of Astronomical Hypotheses which was an introduction to the astronomical system of Hipparchus and Ptolemy. See Heiberg Science and Mathematics in Classical Antiquity: 95. See Heath, The History of Greek Mathematics v. 2 : 535. This book contains a description of the method of measuring the sun’s apparent diameter by

means of Heron's water-clock. In this same book Proclus discusses annular eclipses of the sun. See *Ibid.*: 536.

⁸⁶ Justinian issued a decree against teaching by pagans. Neugebauer, A History of Ancient Mathematical Astronomy, v.2: 1031.

⁸⁷ Heath, A History of Greek Mathematics v. 1: 309

⁸⁸ *Ibid.* v.1: 354 . Neugebauer, A History of Ancient Mathematical Astronomy, v.2: 893. Euclid, Opera VII: 2-141.

⁸⁹ Heath, A History of Greek Mathematics v.2: 16.

⁹⁰ Now lost. Neugebauer, A History of Ancient Mathematical Astronomy, v.2: 893; For a fragment see Heiberg ed., Archimedes, Opera II: 549-551; also Lejeune, Catoptrica Graeca: 142-145.

⁹¹ The burning of the Roman ships in Syracuse by Archimedes was thought to be a myth until, in 1973, it was proven possible by the experiment conducted in the island of Salamis by I. Sakkas. In this experiment 70 copper-plated flat reflectors were used. Ioannis Sakkas, "O Archimedes Ekause ton Stolon ton Romeon di Epipedon Katoptron" [Archimedes Burned the Roman Fleet by Flat Reflectors] Technika Chonika [Technical Chronicles] (September 1973): 771-778.

⁹² Heath, A History of Greek Mathematics vol. 2 : 126

⁹³ *Ibid.*: 194

⁹⁴ Neugebauer, A History of Ancient Mathematical Astronomy, v.2: 893. and Toomer, Diocles on Burning Mirrors: 2.

⁹⁵ Neugebauer, A History of Ancient Mathematical Astronomy, v.2: 893; also see Schöne, Damianos: 22-31.

⁹⁶ Neugebauer, A History of Ancient Mathematical Astronomy, v.2: 893; Nix-Schmidt ed., Heron, Opera II, 1: 303-365, 368-373, 406-415 and Schöne ed. Opera III; also R.E. Suppl. 6 cols. 1287-1290; also Lejeune, Catoptrica Graeca: 137-142. His directions for setting up an automatic theatre found great favor in the Renaissance and among the Arabians; they are responsible for all the fountains with automatic moving features. Even the old cathedral clock of Strassburg, which has so often been imitated, is a direct descendant of Heron's automatic theatre. Similar toys, puzzle-glasses, and the like, occupy most of a Catoptrica, preserved in Latin, derived from Heron. Heiberg, Science and Mathematics in Classical Antiquity,: 85-7.

⁹⁷ Heath, A History of Greek Mathematics v. 2 : 352-354

⁹⁸ *Ibid.*: 273

⁹⁹ *Ibid.*:293; aslo Lejeune, Catoptrica Graeca: 9ff, 17, Lejeune, Ptolemeus' Optics: 10ff, 31ff.

¹⁰⁰ Neugebauer, A History of Ancient Mathematical Astronomy, v.2:894. Lejeune, Catoptrica Graeca:ch. 5, 6; 55, 2; 60, 21; 61, 8. Lejeune, Eucl. Ptol.:22ff;75f.

- 101 Heath, A History of Greek Mathematics v.2: 356
- 102 Ibid.: v.1: 441
- 103 Lived about 379-95. Ibid. vol. 2 :526. Neugebauer, A History of Ancient Mathematical Astronomy, v.2: 893. Euclid, Opera VII: 144-284.
- 104 Heath A History of Greek Mathematics vol. 1 : 444
- 105 Heiberg, Science and Mathematics in Classical Antiquity, : 94. Also Heath, A History of Greek Mathematics vol. 2: 528.
- 106 Ibid.: 25
- 107 Heiberg, Science and Mathematics in Classical Antiquity,: 95-6.
- 108 Neugebauer, A History of Ancient Mathematical Astronomy, v.2: 1032.
- 109 Ibid.: 1042.
- 110 Heath's dating of 70 B.C. v.1: 264 erroneous see Toomer, Diocles on Burning Mirrors: 2. See also Heath, A History of Greek Mathematics v.2 : 200
- 111 Huxley, George Leonard, Anthemi of Tralles: A Study of Later Greek Geometry (Cambridge, MA: Greek Roman and Byzantine Monographs, Eaton Press Inc. 1959): 10
- 112 Cameron, "Isidore of Miletus and Hypatia: On the Editing of Mathematical Texts,": 121
- 113 Heath, A History of Greek Mathematics v. 2: 25
- 114 Ibid.: 540, 543.
- 115 Cameron, "Isidore of Miletus and Hypatia": 120 and note 60. Also, Warren, Greek Mathematics and the Architects to Justinian (London 1976): 8 note 6. According to Cameron, Isidorus' commentary is mostly based on his own experience with vaults as an architect rather than on study of Heron's work. It has been supposed that this commentary was relevant to the building of Hagia Sophia. Warren, Greek Mathematics and the Architects to Justinian: 8 n,6) but this work could not have been written later than ca. 520. Therefore, Isidorus had doubtless been building vaults all his life, Cameron, "Isidore of Miletus and Hypatia: On the Editing of Mathematical Texts,": 120 and note 60.
- 116 Toomer, Diocles on Burning Mirrors: 18-20
- 117 Ibid.:18 note 2, Tannery "Eutocius" Also Toomer, Diocles on Burning Mirrors: 1, 18, 18 note 2.
- 118 Ibid.: 18
- 119 Ibid.: 15-7
- 120 Ibid.: 21. Further proof to this is the fact that it was translated into

Arabic

¹²¹ Cameron “Isidore of Miletus and Hypatia”: 121; Toomer, Diocles on Burning Mirrors: 18

¹²² Downey, “Byzantine Architects, their Training and Methods”: 99-118

¹²³ Heiberg, Science and Mathematics in Classical Antiquity: 103-4.

¹²⁴ Professor Ousterhout revealed that a practical system employing ropes was in effect for the construction of the entire church from a simple plan. Evidence of this system is found in written accounts of the lives of Saints. Professor Ousterhout refers to architectural practices followed in the post-iconoclastic period and his argument is based on hagiographic sources and manuscript illuminations. Robert Ousterhout, “Byzantine Hagiography and the Art of Building,” Abstracts of papers - 19th Annual Byzantine Studies Conference (New Jersey: Princeton University, 1993): 80-81.

¹²⁵ Professor Moutsopoulos has presented a comprehensive system of proportions which allows a builder to derive quite simply the dimensions of various structural members and architectural elements based on the floor plan. He has been able to apply this system successfully to the restoration of certain Middle-Byzantine churches. Nikos Moutsopoulos, “Morphologikes Pratereseis kai Armonikes Haraxeis stous Eggegrammenous Stauroeideis Naous” [Observations on the Morphology and Proportions of Churches of the Inscribed Cross Type] Chronika Aisthetikes [Chronicles of Aisthetics] (1963): 119-130.

¹²⁶ Such a practical system for the orientation of 19th century English churches is described by Lockyer. Lockyer, The Dawn of Astronomy. A Study of the Temple Worship and Mythology of the Ancient Egyptians: 95-98.

¹²⁷ The material of this section was presented as part of a paper entitled “Anthemius’ Design of an Elliptical Mirror and the Dome of Hagia Sophia” at the 20th Annual Byzantine Studies Conference held at the University of Michigan, Ann Arbor, on October 20-23, 1994.

¹²⁸ Huxley, Anthemius of Tralles: A Study of Later Greek Geometry : 6-9.

¹²⁹ Chapter 5 of this dissertation.

¹³⁰ The title has also been translated as “On Remarkable Mechanical Devices”, Cameron, “Isidore of Miletus and Hypatia”: 121.

¹³¹ The English text of the problem under consideration is included in Appendix 4 for convenient reference and is related to Fig. 4.20. Anthemius in Huxley, Anthemius of Tralles: A Study in Later Greek Geometry : 6-9.

¹³² Huxley, based on writings by the nearly contemporary historian Agathias, alludes to the possibility that the mirror, described in the excerpt under discussion, was used along with other devices as a practical joke against the orator Zeno, who was Anthemius’s enemy. These devices had, supposedly, enabled Anthemius to cause an earthquake-like sensation around Zeno’s house. According to Agathias, Zeno while speaking in public, referred this happening as an earthquake, and as a consequence lost popularity. Agathias, Historiae, 5, 7f

¹³³ It is not a focusing reflector, which would have had an excessive blinding and possibly also a burning effect. Nor would it have had a sudden effect as some other devices, involving steam power, described by Agathias. For the purpose described in the anecdote a planar, mobile reflector would have sufficed.

¹³⁴ This becomes all the more evident if the problem that follows this one is considered, wherein Anthemius explicitly refers to burning mirror arrangements and designs.

¹³⁵ Huxley, Anthemius of Tralles: 6

¹³⁶ Point A

¹³⁷ Point B.

¹³⁸ He seeks to resolve the problem in its most specific form because he is probably not fully aware of the reflective properties of the ellipse. This supposition is also in accordance with Toomer's statement that Anthemius might not have known the work of Diocles. Toomer, Diocles on Burning Mirrors : 18.

¹³⁹ As reproduced in Huxley's monograph.

¹⁴⁰ The azimuth angle used between equinox and winter solstice is about 29°. Taking into account the heights of mountains of the Eastern horizon of Istanbul found in the Operational Navigational Map of the U.S. Defense Mapping Agency (Fig. 4.22), the angle between equinoctial and winter solstitial sunrise is about 30°. The azimuth angle used in Anthemius' diagram between equinox and summer solstice is about 38°. This angle is found to be about 37° from calculations from the same map.

¹⁴¹ "Antoniades asserts that, during the reign of Justinian, the center of the sun, when fully risen above the marine horizon, would stand on Christmas Day at a point 31° 41' to the south of East. But since the eastern horizon, as seen from Constantinople, is bounded by the mountains of Bithynia, the center of the sun, fully risen above the hills, would be found on Christmas to stand somewhat south of this point" Emerson H. Swift, Hagia Sophia (New York: Columbia University Press, 1940): 18-19.

¹⁴² In his commentary on Anthemius's excerpt, Huxley concentrates on the geometrical aspects of the shape described: "The method of drawing an ellipse by means of a string looped around two fixed points is here described for the first time; it provides a mechanical illustration of a fundamental property of the ellipse, namely that the sum of the focal distances of any point on the ellipse remains the same." In this Huxley agrees with Heath, Biblioteca Mathematica, 73 (1907): 228. "Anthemius is aware that the focal distances of any point on an ellipse make equal angles with the tangent at that point. . . . Another property of the ellipse, of which Anthemius is aware, is that the straight line which joins the focus to the point of intersection of two tangents bisects the angle between the straight lines joining the same focus to the two points of contact respectively. This property of the ellipse is not proved in Apollonius. Anthemius, moreover, provides an elegant method of constructing an ellipse by means of tangents." Huxley, Anthemius of Tralles: 9-10. Two other scholars consider Anthemius' demonstrations clumsy by comparison to classical precedents. Cameron, "Isidore of Miletus and Hypatia: On the Editing of Mathematical Texts," : 121. Toomer, Diocles on Burning Mirrors: 20, 18, 187-201. In fact, these reflective properties, clearly, are the generative force of the entire undertaking. It thus belongs apparent that the thrust of Anthemius' treatise is aimed at focusing on the applied rather than the theoretical aspects of the problem.

Huxley refers to this problem as if it were an exercise on the geometrical properties of the ellipse. However, if one looked at the problem statement itself, the aim is clearly and plainly focused upon directing the sun rays in a quite specific manner. The fact that the resulting shape of the mirror turns out to be an ellipse is purely incidental. This is indicated even more by the fact that Anthemius, in the diagram accompanying the problem statement and its solution, does not even care to draw the entire shape of the ellipse. Huxley comments on the reflective properties of the ellipse as if it were a matter of secondary concern in this problem statement, and he suggests that Anthemius must have known about them from preexisting sources. "Apollonius knew that the ellipse has the property of reflecting all rays through one focus to the other; from III, 48 it is easily deduced. Moreover, there existed a book, to which Anthemius probably had access, "Peri tou Pyriou" [On the Burning Mirror], written by Apollonius himself. . . " Huxley, Anthemius of Tralles: 10. This emphasis on practical application is supported by the observations of two modern scholars. Referring to Anthemius Alan Cameron says: "For an architect he was no doubt a competent mathematician, and he certainly knew how to apply his knowledge to subjects great and small. A complete Arabic translation (unpublished) of On Remarkable Mechanical Devices continues with methods of constructing fairground distorting mirrors". Cameron "Isidore of Miletus and Hypatia": 121. Toomer, Diocles on Burning Mirrors: 20 "The discovery of the Arabic version puts out of court the much discussed issue (Huxley:20-33) whether the so-called Fragmentum Mathematicum Bobiense was part of Anthemius' book. Cameron "Isidore of Miletus and Hypatia": 121 note 65.

¹⁴³ Cameron "Isidore of Miletus and Hypatia: On the Editing of Mathematical Texts,": 121 and Toomer, Diocles on Burning Mirrors: 187-201.

¹⁴⁴ Possibly the curvature of the dome, and half domes as well as pendentives and the mosaics on the walls.

¹⁴⁵ Huxley, Anthemius of Tralles: 6.

¹⁴⁶ Hagia Sophia was built in the period between 532-537. So the dome could not have been built by the time of Anthemius' death. See F. Hultsch, "Anthemios," Pauly-Wissowa-Kroll RE I, 2368 in Huxley, Anthemius of Tralles: 3. However, at least one modern scholar disagrees about the date of Anthemius' death. "There is no evidence that Anthemius did not live to see the completion of S.Sophia". Cameron, "Isidore of Miletus ad Hypatia": 103-127.

¹⁴⁷ The reason this point is stressed here is for the purpose of contrasting this solution, based on Anthemius' directions, to certain sections of Hagia Sophia that appear in Antoniades and Schneider (Fig. 4.24, 4.25). These sections also appear in Swift, Hagia Sophia : 18-9 and Panayiotis A. Michelis, Hagia Sophia (Athens 1976): 22-3. showing curved surfaces outside the window sills. None of these works mentions the source for these curved surfaces or whether they are existing or hypothetical. Robert Van Nice's detailed and authoritative survey of the present dome does not reveal any such surfaces. Of course, the existing dome is quite different from the original dome. It should be made clear, however, that these do not in any way relate to the configuration described here.

¹⁴⁸ Cyril Mango in Robert Mark and Ahmet S. Cakmak, Hagia Sophia from the Age of Justinian to the Present (England: Cambridge University Press, 1992): 43-44.

¹⁴⁹ Procopius of Caesarea, De Aedificiis, vol. 7, .transl. H.B. Dewing (Cambridge Mas.: Loeb Classical Library, Harvard University Press, 1961) I, i, 41-3.

¹⁵⁰ Rendered as “light” elsewhere. See Procopius De Aedificiis v.7, transl. H.B.Dewing: I, i, 29-31.

¹⁵¹ In fact, it has been rendered as “conductor” in a different translation of Procopius’ work. “Now above these arches is raised a circular building of a spherical form through which the light of day first shines; for the building, I imagine overtops the whole country, and has small openings left on purpose, so that the places where these intervals in the construction occur may serve for conductors of light.” Procopius De Aedificiis transl. A. Stewart (London: Palestine Pilgrims’ Text Society, 1896): 8.

¹⁵² *Ibid.*: 176

¹⁵³ Here as well as in the above paragraph “oven shaped mirror” the words especially of the Greek text seem to suggest a curved reflector in three-dimensions. And it is reasonable that in order to accommodate all the hours of the day a three-dimensionally elliptical reflector would be required. Huxley, Anthemius of Tralles: 8.

¹⁵⁴ Procopius De Aedificiis transl. H.B. Dewing I, i, 41-3.

¹⁵⁵ *Ibid.*: vol. 7, :I, i, 41-3.

¹⁵⁶ Procopius De Aedificiis transl. A. Stewart: 9.

¹⁵⁷ A similar kind of mortar base carefully contrived to reflect light is described in detail for another location within Hagia Sophia by Gervase Mathew. “There is evidence for three stages in the preparation of the mosaic of the Mother and Child in the vestibule of Hagia Sophia. . . .The intricate measuring and angling of this mosaic are best explained if it was intended to be seen at thirteen metres from its centre at man’s height from the floor.” Gervase Mathew, Byzantine Aesthetics (London: John Murray,): 29.

¹⁵⁸ See chapter 5 section Other Light Effects.

¹⁵⁹ Mary Luella Trowbridge, “Philological Studies in Ancient Glass,”: 178-9. A curved mirror, according to Diocles, would be constructed of brass. Toomer, Diocles on Burning Mirrors: 48.

¹⁶⁰ Huxley, Anthemius of Tralles: A Study of Later Greek Geometry: 12-15, 17-18.

PART 2

DOCUMENTATION OF LIGHT EFFECTS

Introduction

In this second part the general principles and common attributes of the lighting design schemes are derived based on observations, compass measurements and the documentation of certain historical facts of selected churches from Mount Athos, Thessaloniki, and Istanbul. The examination is concerned with the ways in which the geometry and orientation of the church influenced the occurrence and intensity of phenomena caused by natural light. A computer program developed by Dr. Richard Sears, Professor of astronomy and a member of the dissertation committee, was used for the calculation of sun angles.

CHAPTER V

THE ORGANIZATION OF LIGHT EFFECTS

General Light Scheme

From personal observations as well as descriptions of visitors, it becomes apparent that quite a consistent scheme of natural illumination is at work in Byzantine churches. During the morning service, light first illuminates the area around the apex of the dome (Fig. 5.1). Diffuse light descends slowly from the image of Pantocrator, located at the apex of the dome, to the Evangelists, located at the four pendentives (Fig. 5.2), and then lower and further out to the perimetric walls of the nave and the choirs brightening in proper order the religious hierarchies depicted in distinct zones of frescoes (Figs. 5.3, 5.5, 5.6). As the light descends into the lower parts of the church it is transformed from diffuse into direct light with intense flashes being cast on various images making them come forward from the dim background.

The Pantocrator is illuminated in such a way that he appears to radiate and distribute light to the figures below him in accordance with each figure's position in the hierarchy of holiness. The figures in lower hierarchies are at times illuminated by light shafts



Fig. 5.1 Gregoriou, Mount Athos. Light illuminates first the apex of the dome.

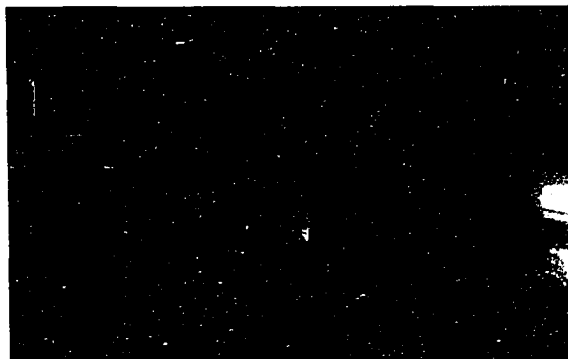
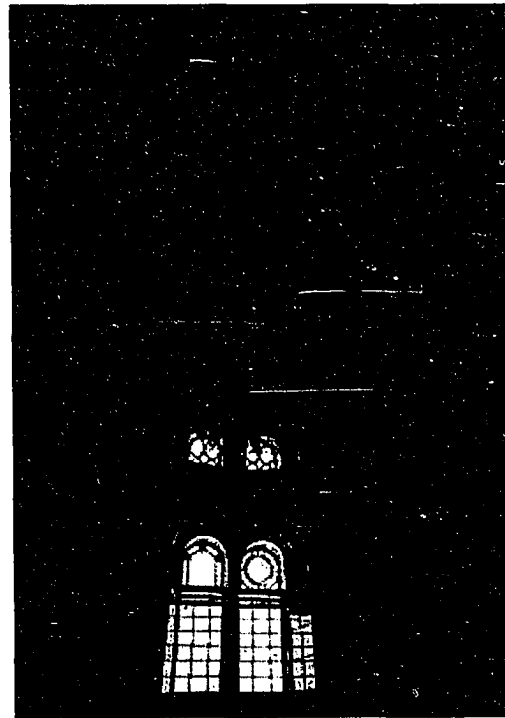


Fig. 5.2 Gregoriou, Mount Athos. Light descends to the Evangelists at the pendentives.



*Fig. 5.3 Gregoriou, Mount Athos.
Religious hierarchies in distinct zones
of frescoes.*



*Fig. 5.4 Gregoriou, Mount Athos.
Golden surfaces attract light.*

while the images contained within the dome, the quarter-sphere of the apse, and the barrel vaults rely on diffuse and reflected light for illumination. No direct sunlight ever reaches these locations which have been reserved for the images of Pantocrator, Virgin Mary, and events from the life of Christ. The golden mosaics or the frescoes of all these concave forms receive light only from reflections since the sunlight enters always through openings located below them. Curved surfaces and golden colors seem to attract light and keep it constant throughout the day (Fig. 5.4).

During the day, light also enters through the choir windows on the north and south sides (Fig. 5.7) lending a symmetrical balance to the space and minimizing strong directional shadows (Fig. 5.8) since almost every object in the nave receives light from three or more sides. Thick, usually beveled, and frescoed window reveals and window sills create zones of transition between a bright exterior and a comparatively dark interior

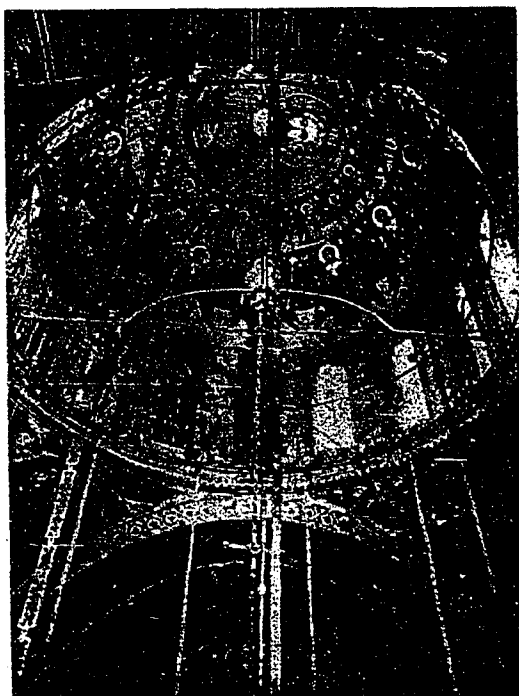


Fig.5.5 Lavra, Mount Athos. Pantocrator, the celestial hierarchy, patriarchs and prophets.

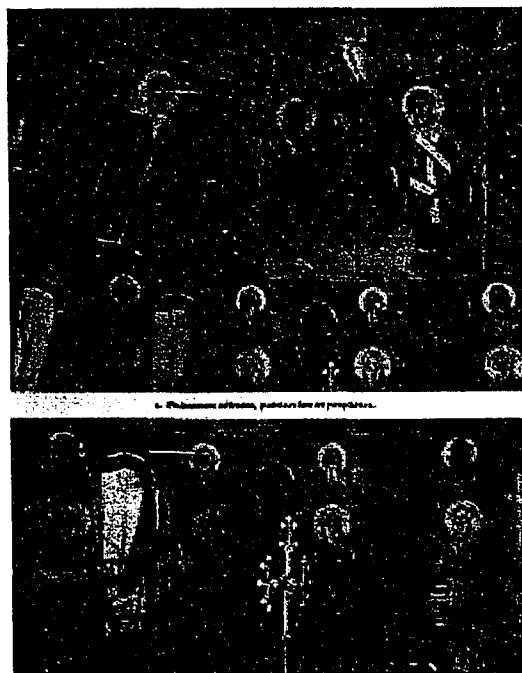


Fig.5.6 Lavra, Mount Athos. Closer view of drum. The celestial hierarchy, patriarchs and prophets.



Fig. 5.7 Gregoriou, Mount Athos. Windows at the N and S choirs.

preventing the eye from being blinded by abrupt leaps in light intensity (Fig. 5.9). Light shafts are visible throughout the day inside the church, becoming most prominent at the beginning and at the end of the day (Fig. 5.10). In some churches light shafts coming through adjacent dome windows often appear to be aimed at different angles, even though they originate at a single source. Because of this perceived difference in the angle of incidence light appears to be in dynamic motion, actively scanning the church interior (Fig. 5.11). During the Vespers, at the end of the day, light is slowly withdrawn to its primal source at the apex of the dome (Fig. 5.12).

Hence, the manner in which light is distributed in the real world has been reversed within the church. While sunlight appears first on the horizon, within the church light is made to appear first in the representation of heaven, the dwelling of God, and then to be distributed slowly in proper order to the lower hierarchies.

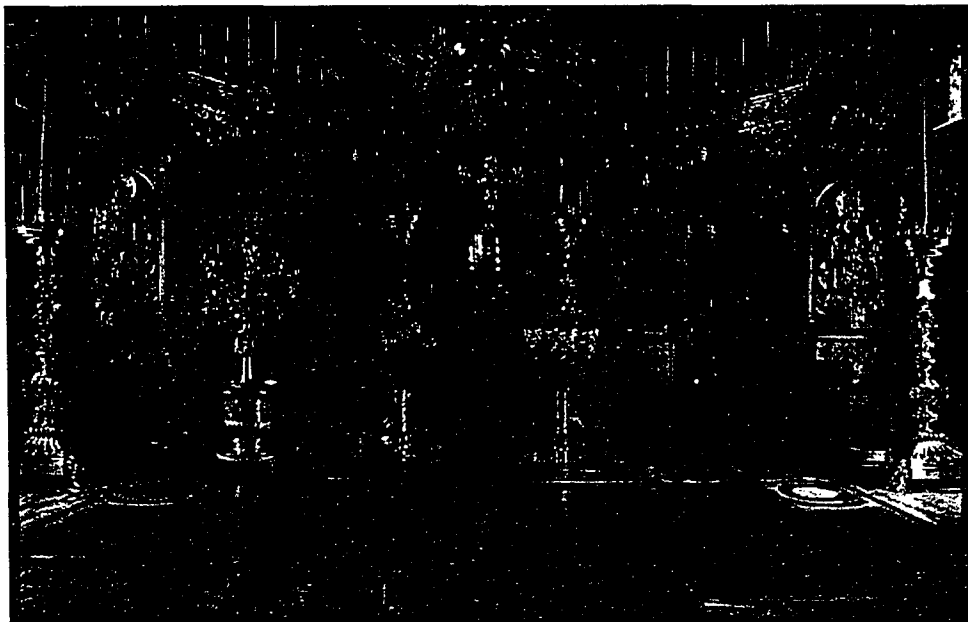


Fig. 5.8 Iveron, Mount Athos. Light is balanced, directional shadows minimized.



Fig. 5.9 Gregoriou, Mount Athos. Thick window reveals form a zone of transition of light.

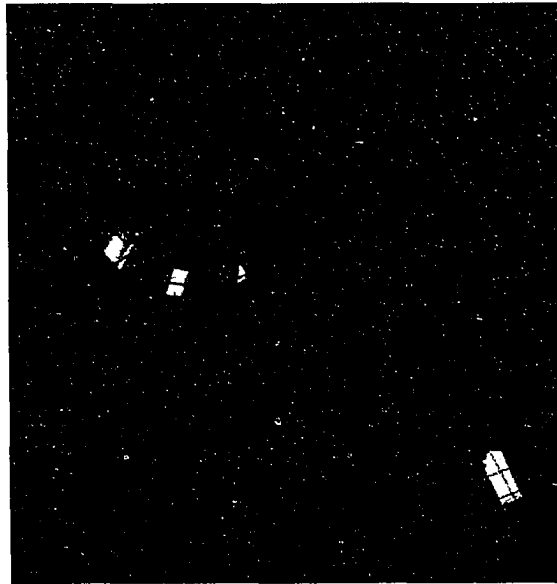


Fig. 5.10 Gregoriou, Mount Athos. Light shafts late in the afternoon.

Visual Organization of Spaces, Images and Light

The impression that the interior makes upon the visitor was of primary concern in the Byzantine church. Indeed, it is widely believed that this type of building was designed chiefly with the interior space in mind.¹ For this reason, visual access to the various parts of the interior was carefully controlled. The method of controlling and sequencing the revelation of images has been the subject of a theory advanced by Marinos Kalligas and its basic outline will be presented here because of its direct relevance to this study.

According to this theory, the development of the size and proportions of architectural elements was dictated, by liturgical requirements in respect to the manner in which the sacred images were intended to be perceived by a person entering the church.² This fundamental concern provided the basis for the layout of spaces and forms. The lighting was also carefully manipulated so that it could be appropriately integrated into the service. The service of the Matins was filled with the anticipation of light—both the real and

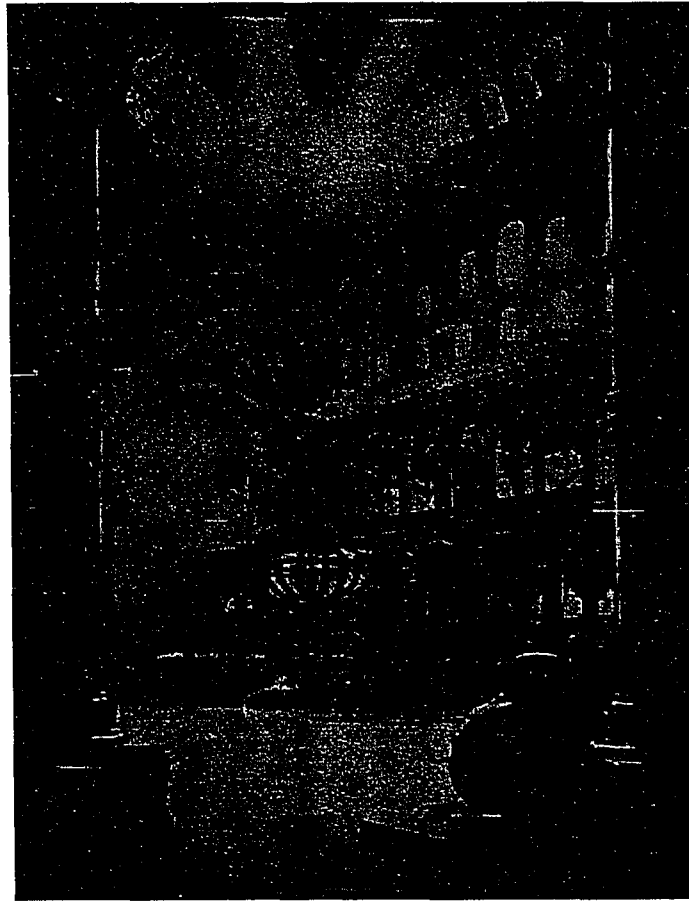


Fig. 5.11 H. Sophia, Istanbul. Light appearing to be in dynamic motion.

the symbolized. The liturgy followed, beginning when the first rays of the sun fell on the dome and the apse. This has been described by both the historian Procopius and the poet Silentiarius in their accounts of Hagia Sophia in the sixth century.³ In the process of entering the church, Kalligas notes, the first thing one saw precisely at the moment one reached the threshold was the main apse being outlined through the *Oraia Pyle*, (beautiful gate),⁴ situated across the narthex.⁵ Usually this gate was completed upward by a concentric arch (if projected at the same plane) with the quarter-sphere covering the apse (Fig. 5.13). At the lower part of the apse, and before it, a low parapet or balustrade was originally located which was later transformed into the iconostasis or screen.⁶ Approxi-

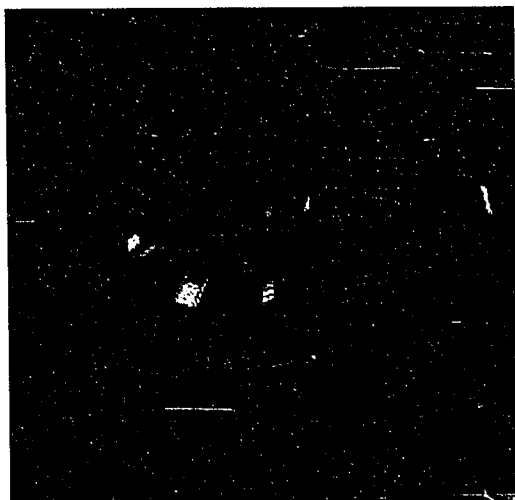


Fig. 5.12 Gregoriou, Mount Athos. Light is withdrawn to the apex of the dome during the Vespers. Esonarthex.

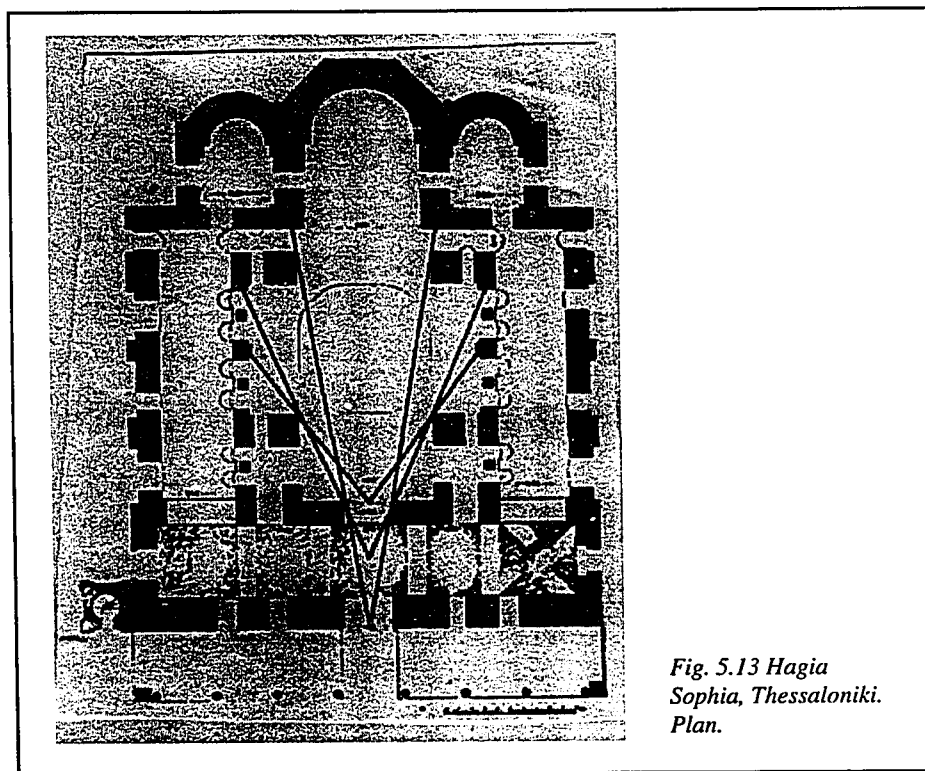


Fig. 5.13 Hagia Sophia, Thessaloniki. Plan.

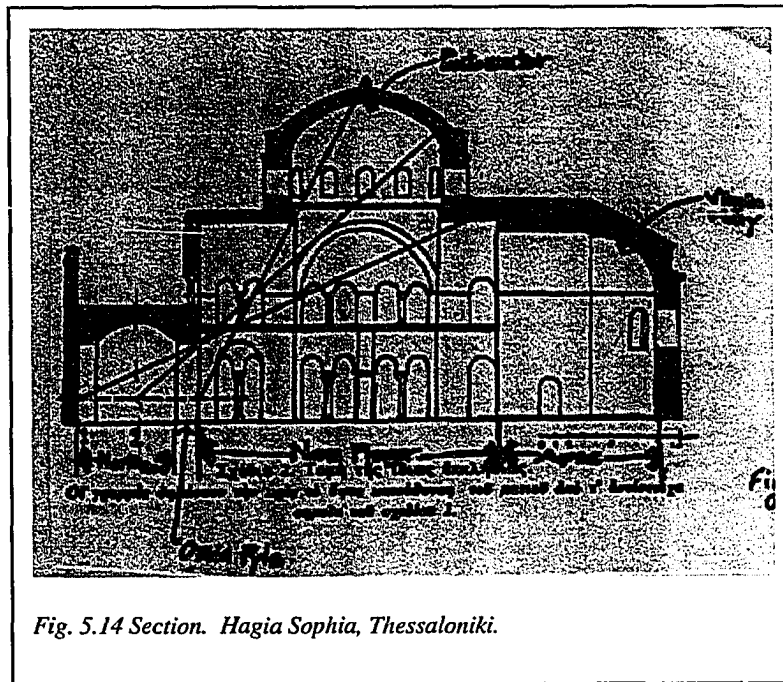


Fig. 5.14 Section. Hagia Sophia, Thessaloniki.

mately in the middle of the apse the richly lit windows were located and higher than that, in the quarter-sphere of the apse, one usually saw the representation of Mary. What one saw changed continuously as one moved from the outer entrance through the narthex. Until one reached the middle of the narthex one only saw the basis of the dome, while on either side of the apse two smaller apses opened up which were similar to the central apse (Fig.5.14). Kalligas observed that the main feature, the image of Christ Pantocrator on the main dome, was not visible before one reached the *Oraia Pyle*.⁷ In order to be able to see Christ, the faithful had to proceed further up, past the gate, exactly at the point where the nave proper began. There, one would linger for a moment in order to glance at the summit of the nave, which had remained hidden until then. At the same time, the entire width of the nave was revealed.⁸ According to this theory, the succession of images were tightly interrelated and each image was a preparation for what followed, like an introduction which was slowly developed to reach the brilliant culmination in which the whole breadth and height of space was revealed.⁹ Kalligas maintains that in this movement - -

from the entrance, through the narthex, and toward the center of the church - - was based the total aesthetic effect of the Byzantine church. If one followed carefully the movement of the faithful's eye during the process of entering, one would discover that its general direction defined a line that in the beginning was almost horizontal, and as the faithful proceeded, it turned upward because the eye sought to discover where the light came from (Fig. 5.14).¹⁰ Too, while the vertical lines and the darker places drove the sight away, the curvatures and the brighter areas attracted it. The fact that the light came only from the apse and from above, had been arranged intentionally, he says, because it helped in the general impression of uplifting that was intended by the church.

According to Kalligas, the main reason for this arrangement was that the narthex was designed to host the catechoumens¹¹ and the third category of Christians.¹² But, also, the faithful had a choice whether to take a step forward toward the nave or whether to remain back in the narthex hidden and burdened with the weight of their sins. Because, according to the Gospel, "the wrongdoer hates light and does not come toward light, so that his deeds are not checked; but the righteous comes toward light."¹³ When the gates opened the faithful entered into the nave as into paradise, while the catechoumens remained outside, by this act stating that the faithful had been raised to heavens having already found entrance in the holy of holies, and that they ascended toward light and they approached and adjoined the throne of the Lord.¹⁴ During the most sacred part of the liturgy, the Eucharist proper, the *Oraia Pyle* was closed so that no sinner or uninitiated could participate or hear.¹⁵ The spatial and iconographic elements were laid out so as to enhance, visually, the distinction between narthex and nave as well. The catechoumens, Kalligas continues, felt an attraction toward the light coming from above, which was the point they had to reach, the final goal toward which their eyes had to turn. Their wish was to be able to see Christ, God, the "true light". From where they were, however, they looked at the image of Mary, located in the quarter-sphere of the upper part of the apse. Mary was thought to be the embodiment of "the route toward salvation", "the hope", "the

mediator”, “the foundation of faith”, “the savior of the sinners.” Looking toward her and sensing, at the same time, the presence of the door (the *oraia pyle*) before them (to them forbidden to pass) they had the feeling that the gate was controlled by Mary and so they prayed to her: “Virgin Mary (Theotoke), Gate of Heavens, open to us the door of thy mercy”. And toward Christ at the dome: “Toward Thou I raised my eyes that thou dweleth in heaven”, or “Because from thou, source of life, in thy light we shall see light”.

¹⁶ The catechoumens are those, Kalligas continues, who are waiting to be enlightened or illumined (φωτιζόμενοι), literally and metaphorically, and in prayers on behalf of the catechoumens many words that are products of light appear time and again, such as: “Let the faithful pray for those brothers who wish to receive the Holy Enlightenment”, or “Let us pray to the Lord to enlighten them with the light of knowledge and devoutness.” ¹⁷ Kalligas maintains that, even though these were symbolic expressions, the Byzantines sought to find a visual expression and as concrete a form as possible. ¹⁸ When, finally, the catechoumen would be allowed to enter the nave, he would feel an openness and relief from burden by proceeding toward light (the dome being the brightest area of the nave). Raising his eyes toward the dome, his soul would be filled with real and spiritual light, sensing a relief from his burden, an upward movement transporting him into a luminous sphere, the sphere of light and faith, the sphere of God. ¹⁹ His soul would rise while his body moved forward. This upward movement of his eyes, Kalligas writes, was followed by an analogous uplifting of his soul; because the mimetic expression that exists in man, which is one of his primeval functions, makes him repeat the motion, the expression of the object he sees and feels in his area. ²⁰ The lighting of the space also helped accentuate the impression created by the architectural members. At the ground floor, the side windows let the space be lit but did not constitute a direct source of light, light did not penetrate directly into the space. Usually, these windows were not seen by the person who moved from the entry toward the interior. Only in the higher regions of the building, consisting in curved surfaces and the dome did light enter the nave directly. Light also

entered directly into the apse, but was confined to its boundaries. Keeping in mind that Mary was depicted above the windows of the apse, one can see how appropriate were the hymns that seemed to be especially composed for the catechoumens in the narthex:

“Brighten Virgin, by the rays of your light, driving away the darkness of ignorance, those who devoutly declare you Theotokos [She who gave birth to God]” and later after the incensing “She, who is higher than the heavens and cleaner than the shine of the sunrays, she, who delivered us from the curse.” ²¹

Hence, this theory, relates church forms and lighting not only to the liturgy and canonical precepts, but also to the resulting iconographic scheme which was briefly examined in Chapter 1.

The Byzantine Dome

According to Michelis, the centralized domed church seems to have evolved conceptually and aesthetically from its predecessor, the Christian basilica, rather than having been introduced as an imported foreign element, as has sometimes been suggested. ²² At the same time, he concedes that there were considerable differences between the Roman and the Christian basilica. In the latter, a sense of depth was enhanced by its terminus in the sanctuary’s apse, whose semicircular shape augmented the impression that space was endless. In the former, the aisles were set on all four sides of the nave, or at least on three of its sides, and the drive towards depth, as a result, was checked (Fig. 5.15). Height in the Christian basilica was stressed by a step-like towering of the roofs of the three or five aisles. In addition the nave was not only emphasized as an *opaion* (a skylight) with windows on all sides of the building, but also branched distinctly out towards the aisles, so that space was not broken up into many relatively independent compartments added to the nave (as in the Roman basilica), but appeared unified (Fig. 5.16). The aisles, as a result, emerged not as an added annex but as a natural growth and by penetrating into the nave gave the impression of raising the interior space towards the

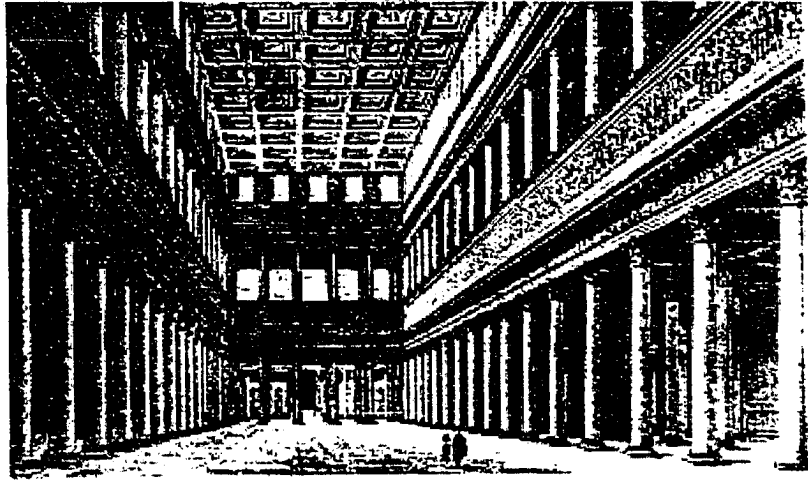


Fig. 5.15 Ulpia Basilica (Roman) reconstruction. Agora, Rome.



Fig. 5.16 Basilica St. Demetrius, Thessaloniki.

illuminated heights. ²³ In contrast to the Christian basilica, Michelis observes, the three interior divisions of the classical temple were usually of equal height and the roof was flat. There was no gradation upward (Fig. 5.15). The space in the Christian basilica appeared limitless in depth, and breathed freely in height, because, thanks to the nave's bright illumination and the usually visible rafters, it seemed almost roofless and evoked a sense of infinity (Figure 5.16). ²⁴ In centrally planned Byzantine churches space was amplified in all directions from the centre more easily than in the Christian basilica because the curved lines, smooth surfaces and low-relief decoration allowed the eye to rove uninterruptedly in all directions; the unity of space was stressed by the central dome. In diverging towards the perimeter from the dome, the central space made a centrifugal movement: it was not placed there by the addition of independent spaces around the center but it was a branching-off, an organic development. Height, moreover, was emphasised in a natural ascent towards the light, along with the gradual rise of the vaults supporting the dome. ²⁵

According to Michelis the representation of God belonged to the dome, ²⁶ which, being the symbol of heaven and therefore the most superb and most brilliantly lighted spot, was eminently suited to receive the reproduction of the Highest Form and Hypostasis. ²⁷ This point is generally agreed upon by scholars. Therefore, the implementation of reflected light toward the apex of the dome was highly desirable and necessary in order to generate the effect of a radiant Pantocrator. Also, in respect to the distribution of light, the liturgically important concept of the condensed liturgical time, discussed earlier, was aesthetically realized and acquired particular power when the Pantocrator appearing stationary, glorious, and constantly lit was overseeing the lower hierarchies depicted on the walls and, lower still, the world of the living; the first (the hierarchies of angels and saints) hovering and revolving below him occasionally brought into prominence by light shafts; the second (the world of the living) by moving on their own. This hovering around the main source of light is replicated by the arrangement of the principal sources of



Fig. 5.17 Iveron, Mount Athos. Chandelier and Chorus of Saints.

artificial light, as well. The main chandelier signifies Christ (merciful God) while the Chorus of Saints forms a circular fixture suspended around the chandelier and being sparsely illuminated by subdued candles or spaced-apart tapers, as opposed to the numerous tapers attached to the chandelier (Fig. 5.17). This arrangement, found in Mount Athos, represents a later development but it is consistent with the same fundamental logic both in symbolic and aesthetic terms.

As noted earlier, the constantly lit dome had both a functional and a symbolic significance²⁸ as the human eye is driven from the darker toward the higher lit surfaces, so too it surely is directed toward the image of God. Especially in the case of catechoumens who were confined in the narthex and were unable to see the radiant image of Pantocrator at the apex of the dome, this aimed at intensifying the hope and expectation that one day they would be able to see Christ, the “true light.”²⁹ Christ Pantocrator’s representations are commonly accompanied by written statements emphasizing this divine trait, such as the epigram found around the image of Pantocrator in the church of Martorama in Palermo: “I am the light of the world, those who follow me shall not walk in darkness but shall have the light of life”.³⁰ Michelis also emphasizes the central role

of light in the Byzantine church. He maintains that irrespective of the subsidiary aids used to convey sublimity, the basic factor was always light, concentrated high above, from where it poured into the mysterious darkness engulfing certain distant parts of the aisles, and so filling the worshipper with wonder and making him ponder the words, "In the Lord's light we shall see light." But, despite its brilliant centre, Michelis writes, the Byzantine church gave a general impression of subdued light. With the brilliance of the Greek sky, he says, it was essential to tone down the light in the interior before the church could produce that atmosphere of recondite mystery which induced a sense of inward-dwelling in the worshipper. The half-light offered by the main church, made the luminous points (like the dome) even more vivid and welcome by contrast.³¹ He refers, of course, to churches of the middle and later Byzantine periods because he openly recognizes that in Early Byzantine times light was abundant in the churches (Figure 5.18).³²

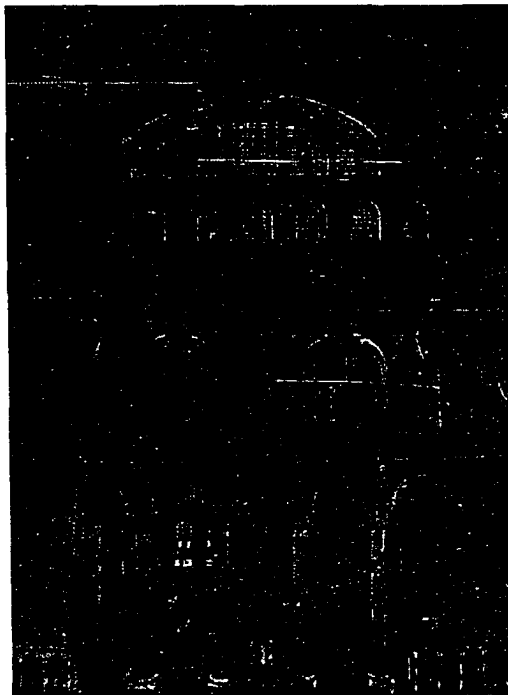


Fig. 5.18 Reworked photograph of the south wall which shows large original openings. H. Sophia, Istanbul.

Examples of Light Manipulation in the Dome

Hagia Sophia of Constantinople and Other Examples

Procopius placed great emphasis on light ³³ in his account of Hagia Sophia. His description of light effects is quite extensive, given the brief treatment that many important issues received in his history of Justinian's reign. He wrote that Hagia Sophia:

... is singularly full of light and sunshine; you would declare that the place is not lighted by the sun from without, but that the rays are produced within itself, such an abundance of light is poured into this church. ³⁴

Hagia Sophia in its original state had many more openings and was, therefore, much brighter than it is today (Figure 5.18). ³⁵ It appears that the main dome contributed also to this luminosity in its own way. It is known that the original dome had a precariously flat curvature which became the cause of its downfall. This unusual curvature has been explained by John Warren, in ways chiefly involving structural reasoning or the absence of sound practices in respect to it. ³⁶ It seems reasonable, however, that the architects' choice, should be attributed not to their lack of knowledge, in which case and if they had simply aimed at structural stability they would have followed time-honored antecedents, but, instead, to their will to defy technological limitations in order to achieve a highly desired effect. The original dome of Anthemius endured for little more than twenty years. It fell on May 557 and was rebuilt by Isidorus the Younger from 557-562. It stood intact until it collapsed again with the western arch in 989 A.D. The third reconstruction was completed in 994 or 995 under the direction of the Armenian architect Trdat ³⁷. The dome fell again in 1346 with the collapse of the great eastern arch. Its fourth rebuilding was completed in 1356 by the emperors Cantacuzenus and John Paleologus I and it was later fortified with chains by the Italian architects the Fossati brothers. With each reconstruction the shape of the dome was tampered with. Therefore, the impression imparted by it today is much removed from what it was originally.

Certain theories have been advanced by various scholars regarding the form of the

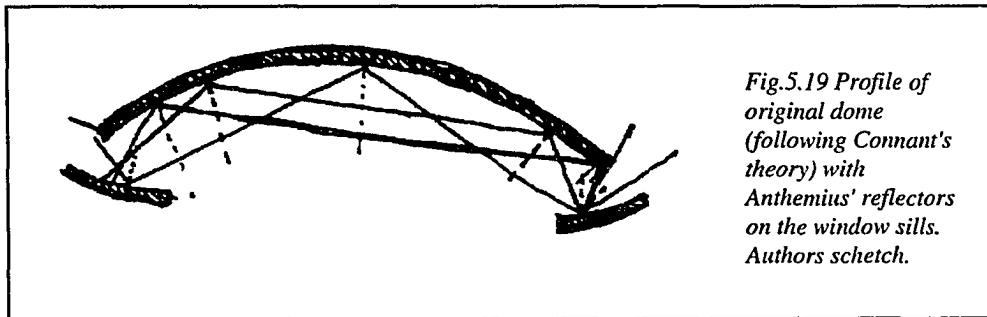
original dome. Each of these theories emphasizes different considerations such as engineering, architectural morphology and typology, perceptual impact, and utility. Although these theories vary somewhat regarding the shape of the original dome in plan, there is substantial agreement among them on that its height was twenty or twenty five Byzantine feet lower than the second one.³⁸ The impact of the slight plan variations proposed by these theories might have been essential for other reasons - - such as the manipulation of perspective - - but would not have been considerable in respect to the effect of light. Conversely, the shallower profile of the original dome would have had a decisive impact on the way light would be captured and reflected by its surface. This is in agreement with Mainstone's observation:

The only significant difference in the character of the interior before the reconstruction, . . . would have been that due to the shallower dome. Its surface would have caught more of the light reflected up from the cornice and the sloping window sills, and this would have accentuated the impression of hovering.³⁹

However, plain sloping window-sills, as Mainstone seems to suggest, would not have resulted in a satisfactory solution. Procopius writes:

. . . the entire ceiling is covered with pure gold, which adds glory to its beauty . . .⁴⁰

It is interesting to note here the use of the word "glory" which had become in Byzantine theological literature synonymous with that enveloping light which was peculiar to God. This kind of light, as we have seen, found its way into the Byzantine pictorial representations as well. From Procopius' statement it can be deduced that the dome ceiling was in essence designed as a reflector because the material used-the golden mosaic-was reflective. The purpose of a reflective ceiling, however, is not very clear and the most plausible explanation is to be found in certain observations made by Gervase Mathew and Thomas Whittemore that in Hagia Sophia, the gentle curving of mosaic surfaces was often used to capture and reflect light.⁴¹ This special property of gently curving surfaces acquires particular relevance here because, as argued so far, the design

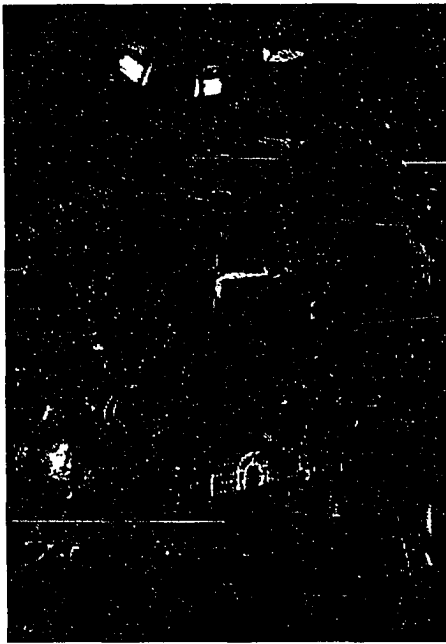


intention had been for the dome to become the most brilliant spot worthy of its aesthetic and symbolic role.

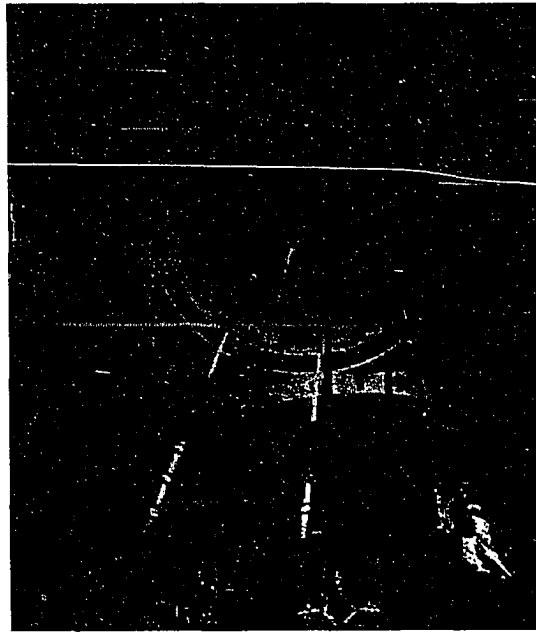
If the motion of additional rays of sunlight are examined as these are directed by Anthemius' reflector, it becomes progressively evident that the shallower the dome the fewer the rays reflected downwards toward the nave of the church. In fact, in a dome profile as shallow as the one proposed by Kenneth Conant ⁴² the light is retained within the cupola being reflected back and forth within its shape (Fig. 5.19).

Thus, the effect of the combination of this dome profile with Anthemius' curved reflector could be summed up as following. On the one hand, the reflectors would ensure that the dome would receive light from the greatest possible number of windows at any one time thus providing the presence of a constant and brilliant light around the apex area throughout the day and the year. On the other hand, the shallow curvature covered with golden mosaic would generate light reflections which instead of being directed downward toward the nave they would remain contained within the dome thus driving away all shadows and achieving an even illumination within it.

The visual effect of this design would be that the cupola would appear completely detached from the remaining portion of the church, creating the impression of an area of light existing on its own accord and bearing no relationship to the ground. In such a situation, the light of the dome would have been perceived as a different, unearthly light,



*Fig.5.20 Gregoriou, Mount Athos.
Pendentives and main dome.*



*Fig. 5.21 Gregoriou, Mount Athos.
Pendentives and main dome.*

similar to the luminous glory in fresco and mosaic representations, entirely detached both physically and metaphorically from the present world. It would be isolated, suspended and hover above, unconnected to the events and occurrences of the world below.⁴³ It would be a wonderful representation and would generate a most convincing impression - - in spatial terms - - of that indescribable divine light, the “superessential” light, the light “that casts no shadows” because, physically, it would not come into contact with any material body.

The Hagia Sophia example discussed above does not constitute, however, the only method for attaining the effect of a luminous dome. Indeed, it represents virtually a unique example and is by far the most sophisticated. A less sophisticated solution would call for the window sills, located just below the curvature, to be substantially deep and assume different slants, depending on their orientation in respect to the azimuth angle of the sun. This method of design is found in the majority of the churches and it can be

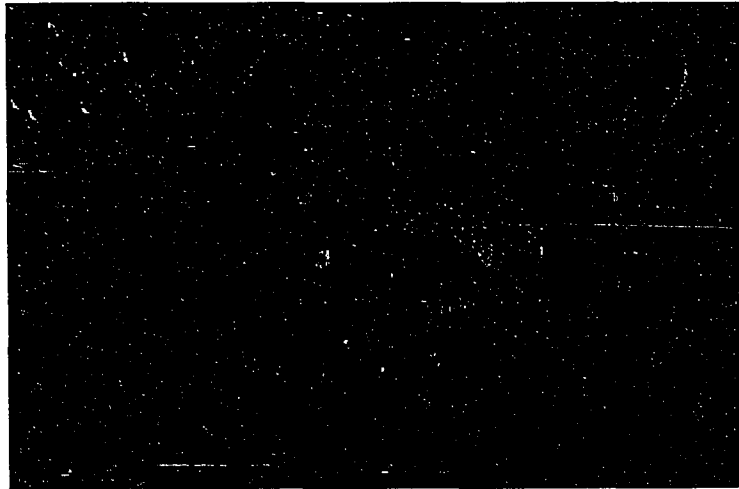


Fig. 5.22 Iveron, Mount Athos. Pendentives of main dome.

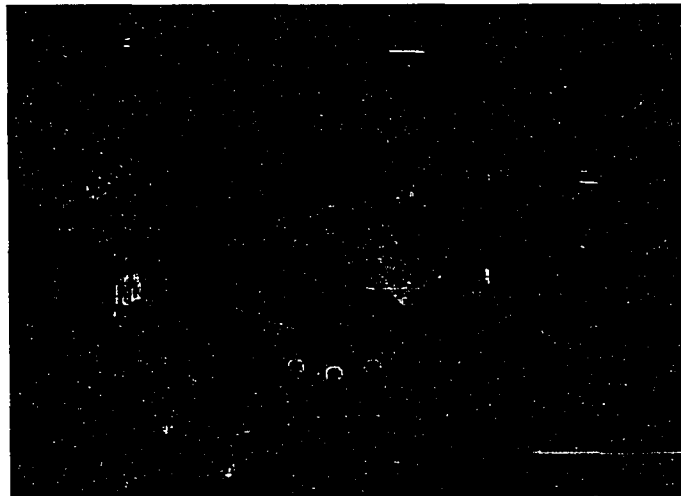
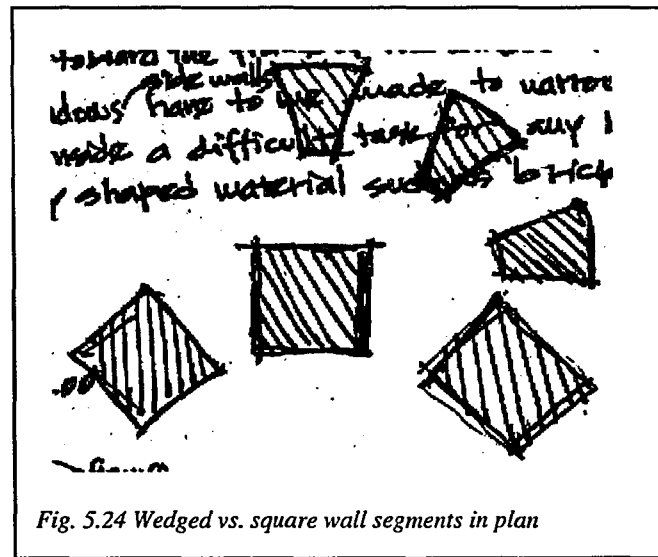


Fig. 5.23 Iveron, Mount Athos. Close-up view of Pendentives

reached by a trial and error process which, presumably, would have been the approach followed by the average builder.

However, this solution had not always been successful. One can often observe Byzantine domes and pendentives, not properly designed in respect to light, to present a heavy irregular and shadowy profile that disturbs the coherence of the design concept and projects an impression of heavy materiality (Fig.5.20, 5.21). In contrast, if the dome is evenly lighted, an airy feeling of immateriality is achieved, as if one were enveloped in



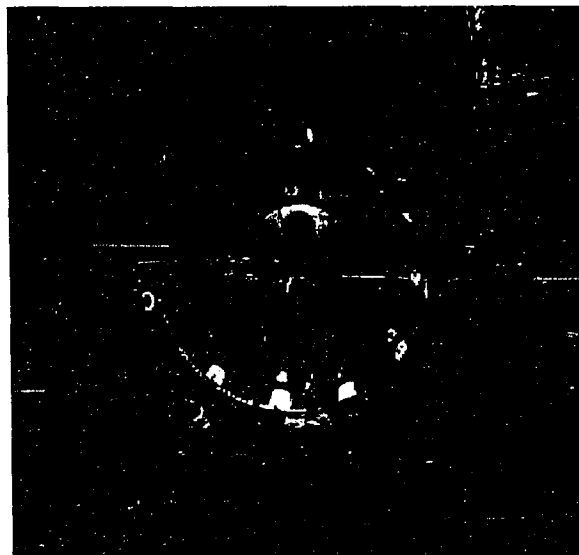
brightness (Fig. 5.22, 5.23).

Deep window sills would accommodate the varying altitude of the sun and consequently would reflect the sunrays with varied angles of incidence onto the dome. If the window sills were appropriately slanted and if the sill of each successive window had a slightly different slant then the dome crown would be sure to receive light from at least one window at a time during the course of the day.

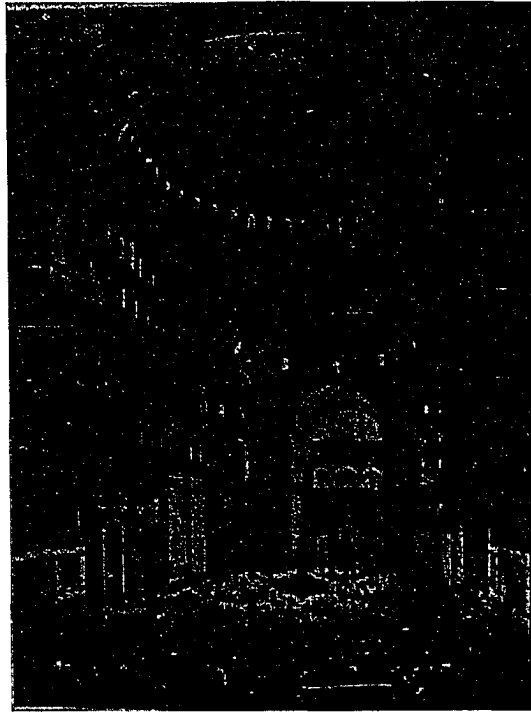
The window sills should be either level or slant outward in order to reflect light closer toward the apex of the dome. One may observe a difference between the window sills of windows intended to reflect light upward and those windows simply intended to receive light into the space. For instance, in the dome windows of Megiste Lavra, the sills are placed in the interior before the window and they slant slightly outward (Fig. 5.33). Also, the window opening becomes slightly wider on the inside. None of these two applications can be rationalized on the basis of constructional ease or sound construction technique. On the contrary, the window pane and frame are not protected from rain; if rain penetrates, the window sill directs it back toward the frame of the window instead of

away from it. Moreover, the wall sections between successive windows are too narrow and too wedged in section (Figure 5.24); a difficult task for any builder who works with rectangularly shaped material such as brick. The only reason for creating window openings of such pronounced profile is to facilitate the admission of light in the desired manner. Widening up the window openings toward the inside allows light to come in for a longer period of time as the sun shifts away. The beveling maximizes the amount and duration of sunlight coming in through that window and striking that particular sill; the sill sends the light up toward the apex.

The image of Pantocrator presented by this technique would have been moderately luminous (Fig. 5.22). In this case the dome windows should be tall enough to minimize the cut-off angle of light directed toward the dome. The deeper the dome in the vertical dimension, the taller the windows would have to be. This observation accords with the size of the dome windows in most Byzantine churches, which is usually directly proportional to the depth of the dome. An interesting illustration of this principle is found in the double-tiered windows of the church of the Dionysiou monastery in Mount Athos



*Fig. 5.25 Dionysiou, Mount Athos.
Two-tiered dome windows.*



*Fig.5.26
H. Sophia, Istanbul.
Large dark areas above
dome windows view.
Looking west.*

which shows that the height of windows was selected not on stylistic or proportional grounds alone but for their contribution of light (Fig. 5.25).

With this more primitive solution for illuminating the dome, a certain area of the dome, depending on the altitude of the sun, would be lit more brightly than others and this would not necessarily correspond with the apex (Figs. 5.26) because, the same azimuth corresponds to different altitudes in the different seasons. Therefore, non-reflective material should be employed in the window sills in order to scatter and diffuse the light throughout the dome. This would be increasingly true the fewer the windows in the dome.

Evidence of a quite remarkable variation of the window sills in the apse (which following the same strategy contribute light toward the image of Virgin Mary) was identified in the apse of Osiou Gregoriou in Mount Athos where two adjacent window sills of the apse slope toward opposite directions. By placing a piece of black paper on

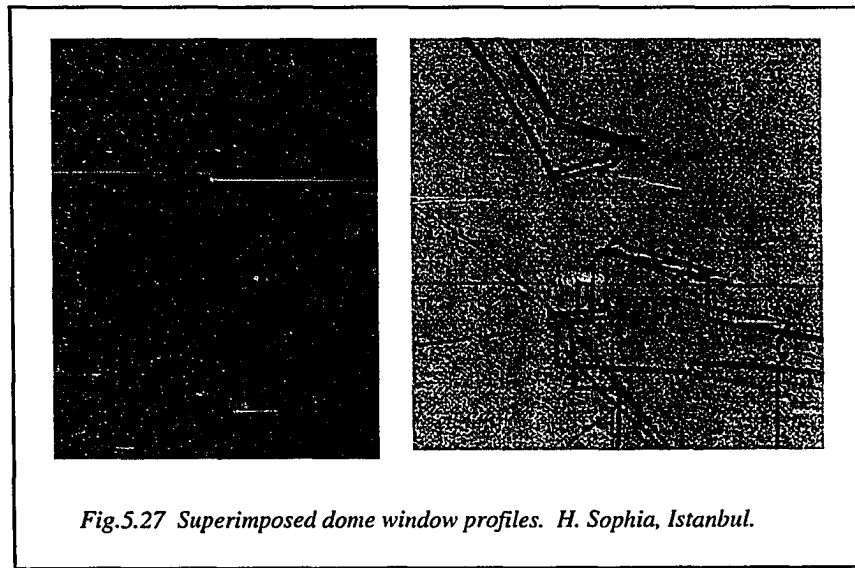


Fig.5.27 Superimposed dome window profiles. H. Sophia, Istanbul.

top of these window sills, the image of Virgin Mary above was immediately darkened. It is notable that the window sills of the apse of Hagia Eirene are flat (Fig. A1.13) a fact which is justifiable by the intent to direct light toward the quarter sphere of the apse. This is also true at the dome window sills of H. Eirene, (Fig. A1.12, A1.13), and those of S. Mary Pammakaristos side chapel are sloping outward which is even a better solution in respect to light reflectance (Fig. 5.30). In addition, a drawing of the present dome of Hagia Sophia by Robert Van Nice shows considerable variations of height and slope among the window sills (Fig. 5.27). Also note the slanting window sills of the lower apse windows whose purpose is to admit direct light onto the altar as opposed to the flat sills of the windows in the middle whose purpose is to direct light toward the quarter sphere of the apse (Fig. 5.41). The present dome window sills of Hagia Sophia do not illuminate the entire dome but they still retain a certain constancy of light at the center (Fig. 5.28, 5.29).⁴⁴ However, the present dome exhibits large dark areas surrounding the central illumined spot. Thus, it appears that similar empirical methods must have been used before and after the design of the original dome of Hagia Sophia which may be described as distant relatives of Anthemius' perfectionist's approach.

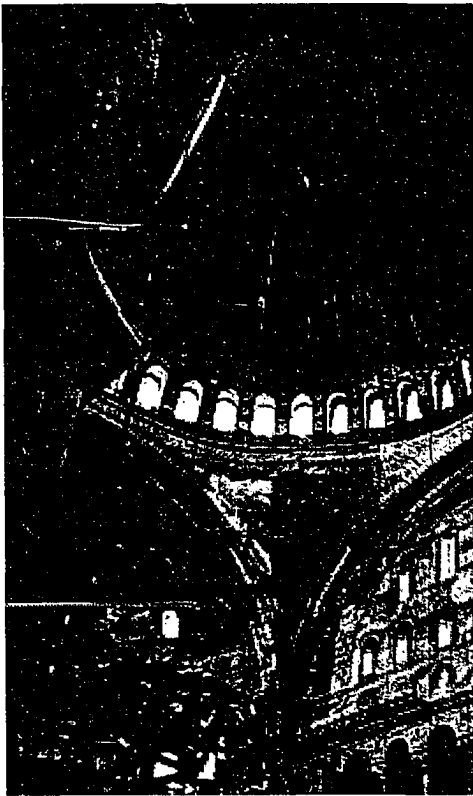


Fig.5.28 Present dome still retains some constant light at the apex. H. Sophia, Istanbul.



Fig.5.29 Bright apex with dark surrounding areas. H. Sophia, Istanbul.

Orientation- Light Shafts in the Apse

According to George Scott there has always been an intimate relationship between the church orientation and the sun which underwent a period of intense experimentation and development in Early Christian times that led to radical changes:

In churches of the medieval period the sanctuary, as is notorious, is placed at the eastern end of the building, and the officiate priest, facing eastward, has his back toward the congregation, or, speaking more exactly, faces in the same direction as they. In the early Christian basilicas the sanctuary was, as a rule, placed at the western end of the church. The priest at the altar, then as in the middle ages facing eastward, had his face towards the people. In other words, the celebrant has, at all periods, faced eastward, while the people, who in early times were before the priest and facing westward, are in later times placed behind the priest, and face therefore, as he does, eastward. Thus the eastward position of the priest has never

varied, but the position of the people in relation to the celebrant has been in the course of ages reversed.⁴⁵

It has been observed that a shaft of sunlight is sometimes cast onto the Holy Sacraments and the altar at the time of their dedication to God on special dates. As explained earlier, this is the most important part of the liturgy and the place where the priest stands while offering the gifts is considered to be the most sacred in the church. At this time he and the bread and wine, which are raised above his head, are bathed in sunlight and it is at this time that the plain offerings are thought to be transformed into Holy Sacraments.

Whether and when shafts of light will occur depends directly on the church orientation and on the location and configuration of the openings. While it is generally accepted that churches should have their apse oriented toward the east, in a large number of churches — including some of the leading examples⁴⁶ — the main axis of the edifice is usually turned sharply to the south of east and sometimes even to the north of east. This considerable variation of church orientation is often loosely attributed to local factors and limitations, such as the unsuitability of the site, or to careless building techniques that are thought to have been the norm during the Byzantine era, or has received a number of equally unsatisfactory explanations.⁴⁷ Moreover, considerable variations among churches are found in respect to the geometry of the apse, and the size, number, and location of the apse windows, the slanting of the window reveals and the further modulation of the windows by perforated panels of varying sizes and patterns. All this design activity in regard to the form and configuration of solids and voids surrounding the apse are only meaningful if viewed from the standpoint of the thesis advanced here, because they suggest intense experimentation in regard to the manner and time that light was to be permitted to enter and illuminate the altar. For this purpose the architect of the church would have to coordinate a number of factors such as the altar position, the window dimensions, the sun position at the time of interest, the form of the apse in plan, as well as the landscape formation as related to the time of sunrise in each particular location.

As discussed earlier, the most important time of day for the occurrence of this event was the *third hour* while the date differed for each church. The most probable dates would be the dedicatory or patron Saint's nameday, the date of the church consecration and the date of the celebration of the founder, if there was one established by the Church. Smaller churches tend to be oriented toward the midmorning sun position of the dedicatory Saint's nameday and are often attended on that day alone. On the other hand, other churches tend to aim toward the midmorning sun azimuth of the days of the equinox. This orientation is usually given to cathedrals and is coordinated with large openings in the apse so that the midmorning sunlight could be directed toward the altar during most of the year (Fig. I.1). The reason for this choice was most probably the fact that cathedrals were used on a regular basis and many high feasts were celebrated in them. In addition, the equinox and the summer and winter solstices often played a key role in the orientation of large cathedrals, this was due to the fact that, on the one hand Christian festivals were originally and traditionally related to these important moments of the solar cycle and, on the other, the consistent reoccurrence of these events at the same point in the horizon regardless of the accuracy of the calendar used.

There arises the question of whether it is possible to design for the actual visibility of a light shaft. In other words, was it intentional that the light shafts were made visible or was it an accidental phenomenon? According to Minnaert the visibility of light shafts generated outdoors in a cloudy day, is due to voids between the clouds and the interference of direct light and light reflected off the side walls of the clouds.⁴⁸ If one supposes that this claim is true then a similar interference occurs in the church because the church windows are built with deep window reveals sloping in such a way as to be visible from the interior of the church. In this way the light coming through them is a combination of both direct and reflected light. Thus, the interference of the direct light and that which is reflected off the window reveals is, according to this logic, responsible for the generation of light shafts. The visibility of the light shafts would have been intensified by the use of

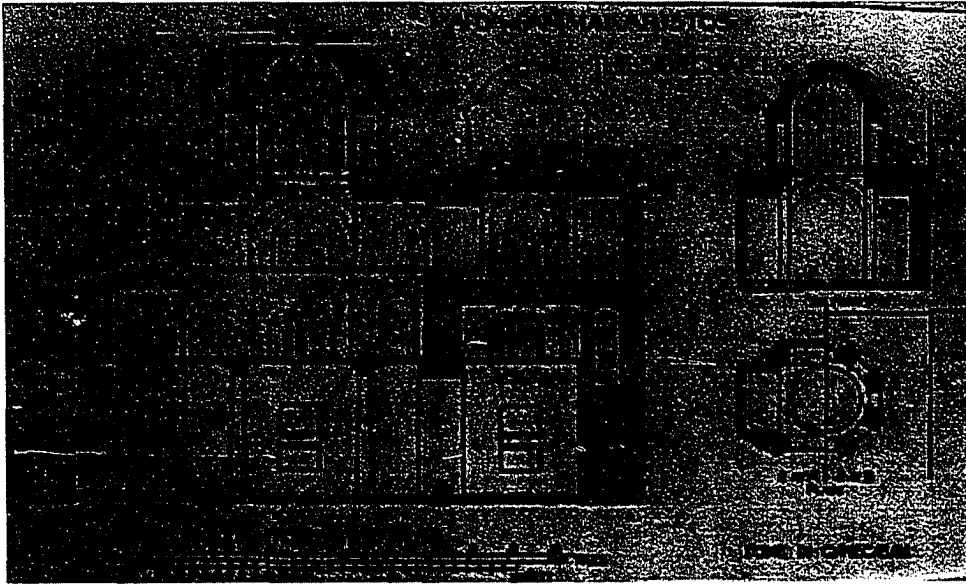


Fig. 5.30 St. Mary Pammakaristos, side chapel, Istanbul. Dome window sills sloping outward.

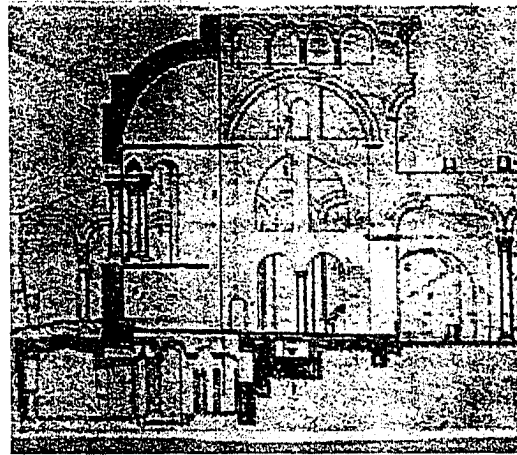
translucent glass which appears to have been in common use in the Early and Middle Byzantine periods.⁴⁹

Shafts of light are not visible to everyone in the church. Whether these shafts are seen depends on the position of each person within the church and on the angle in which one faces the light shaft. This strengthens the fleeting impression created by the immateriality of light and is in agreement with the concept that God is revealed to each human being according to the latter's capacity and readiness to receive Him.

In most cases even though the occurrence of light shafts is clearly discernible today, there does not seem to be a liturgical purpose in connection with it for the following reasons. To begin with, the time of the liturgy is freely arranged today according to the needs of the community and does not follow the precise Byzantine schedule. In addition, the time measurement today is based on mechanical clocks that measure time in equinoctial hours and thus are not related closely to the motion of the sun. Then too, the error of the Julian calendar has, to a certain extent, confounded the dates in which these

occurrences were designed to take place. Finally, the original dedication of most churches no longer holds. This last reason constitutes perhaps the most destructive interference: if the church were given an orientation which would endow the building with a special radiance or which would allow light shafts to illuminate specific locations during the feast day of the Saint to whom the church was dedicated, any changes in the dedication of the church - - and thus in celebration date - - would naturally result in having special light effects take place on a date of no particular importance to the specific church. So, none would be capable of making a connection between the two.

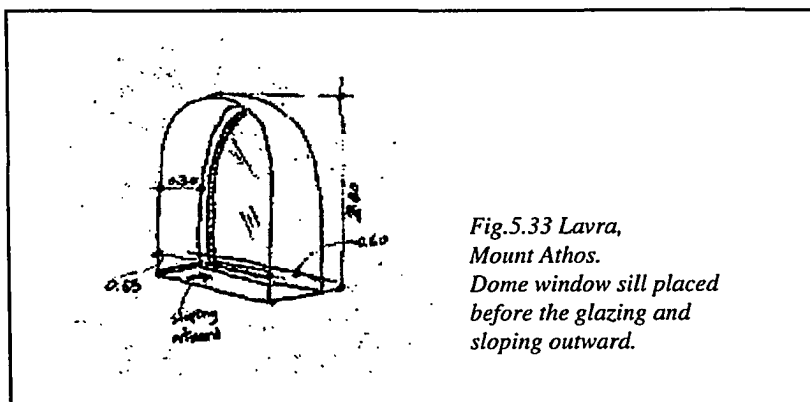
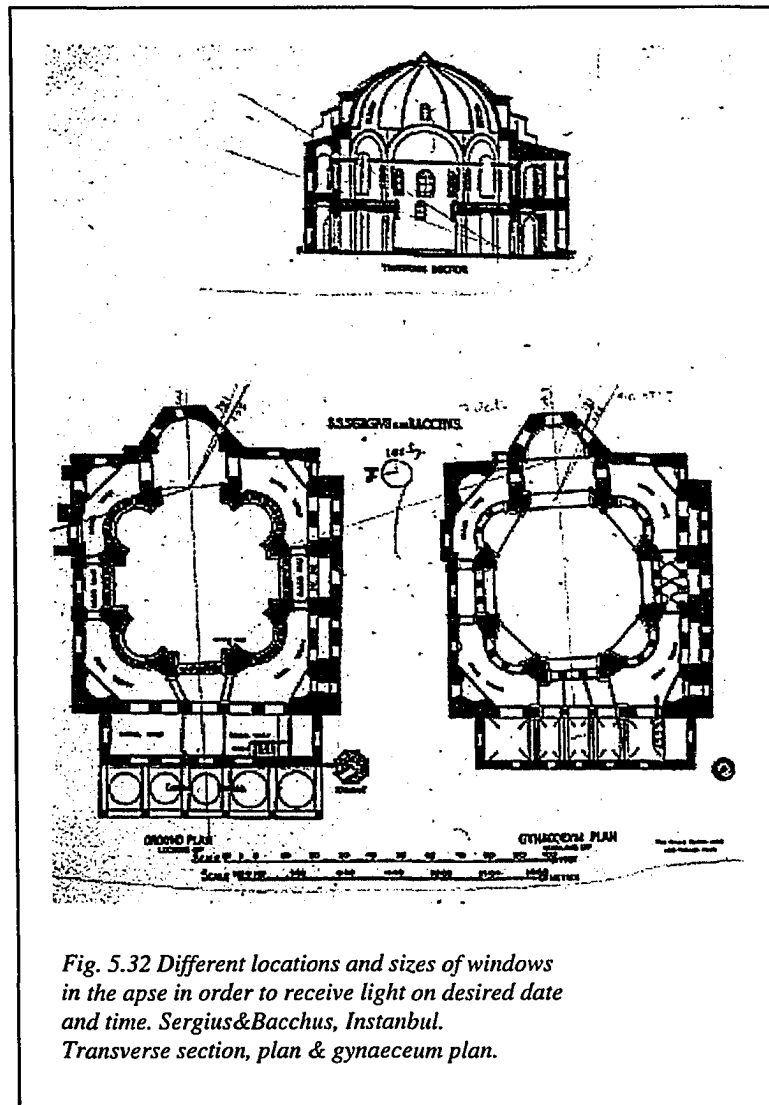
In some cases light shafts can still be experienced today in connection with significant occasions on Mount Athos. Kalligas has noted that shafts of light in the Byzantine church become especially powerful and visible at the times that the sun is low in the horizon, which usually correspond to the most significant liturgical times.⁵⁰ Regarding the form of the apse and the number of openings in it there is a number of varied solutions. It is often mentioned that three windows are employed in the apse in order to symbolize the Holy Trinity.⁵¹ Yet, this does not appear to be a universal solution. Many churches have bilobe windows (Fig. A1.16) whereas the Hagia Sophia of Istanbul contains six large and five small ones (Fig. 5.29) and in St. Demetrius of Thessaloniki there is an enormous continuous window extending over the entire exterior wall of the apse (Fig. 5.31). Although three openings may often appear in the plans of individual churches, their elevation typically contains a greater number of windows in order to allow light to shine onto the altar for more than one occasions throughout the year. Thus, in winter, when the sun rises closer to the South, the position of the sun and the position of the priest during the consecration of the Holy Sacraments in the Bema align through the right southernmost window of the apse. In the spring and autumn, on the other hand, such an alignment would occur through the central window; in the Summer through the northernmost window (Fig. I.1). The exact alignments may vary, depending on the emphasis placed on the particular feast days established for each church. It is interesting to note in

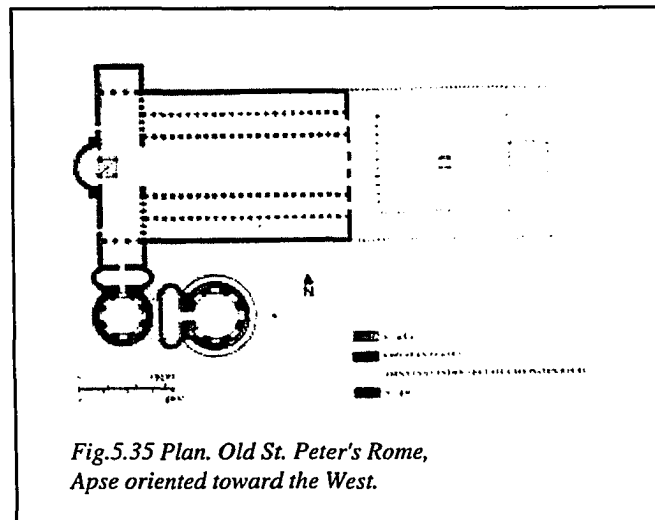
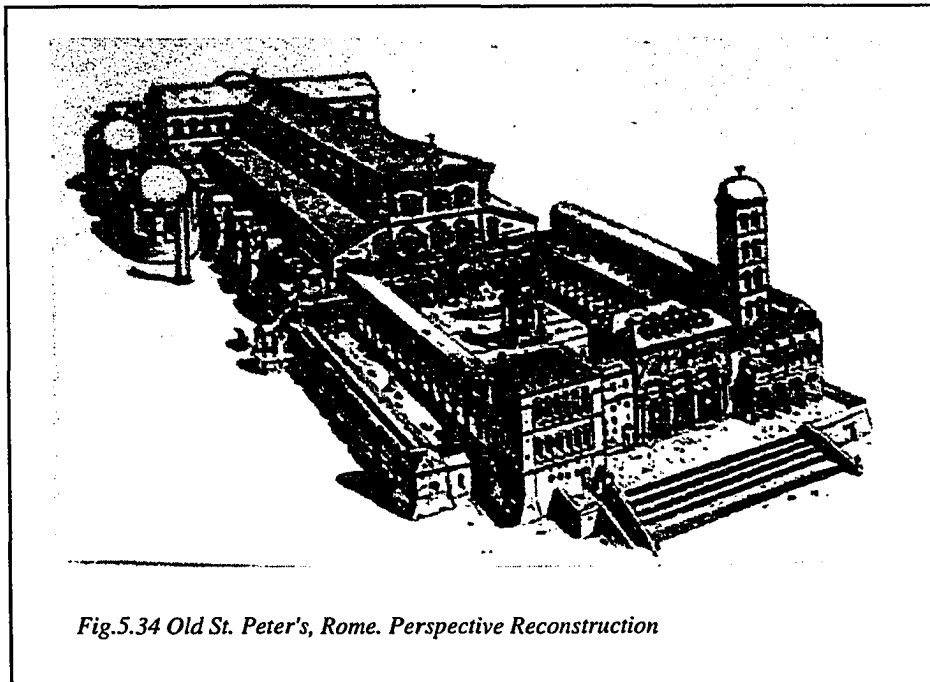


*Fig.5.31 St. Demetrios, Thessaloniki.
Continuous apse window.*

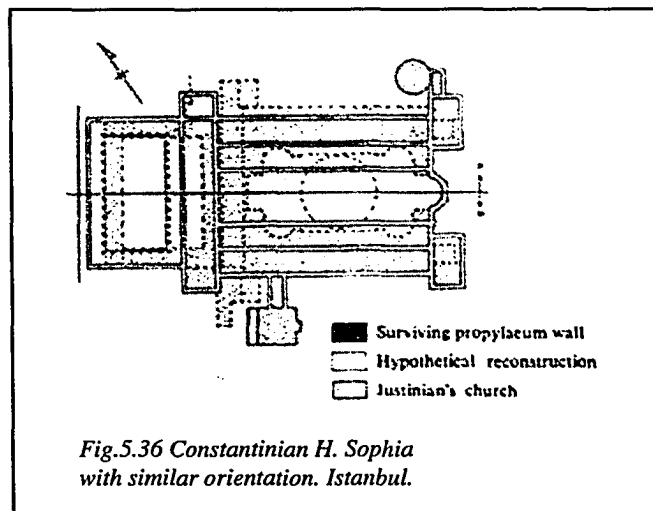
this regard, that the apse assumes various polygonal or cylindrical forms a choice which was made by Byzantine architects probably in order to appropriately orientate the apse windows in each individual case. Occasionally the use of a particular polygonal apse form would conflict with the harmonious relationship of windows and wall segments, as these relate to the position of the sun on the desired dates, resulting in unsightly solutions such as in the church of St. Sergius and Bacchus (Fig.5.32). In this church the lower southern most window admits light onto the altar during the Saint's nameday on October 7th.

The careful observation of certain construction details of windows also reveal the presence of an alertness in respect to the behavior of natural light. As mentioned earlier there is no constructional rationale for having window sills sloping inward. Even less justifiable is the case in which an outward sloping window sill would be placed before the glazing.(Fig.5.33) Sound building techniques dictate that glazing should be placed at the innermost surface of a window opening in order to protect the glazing frame and membrane from rain and moisture. Moreover, the window sill should be placed outside the glazing and slope outward in order to easily get rid of excess water. Only a rationale





related to the admission of light could serve as the determining factor for creating an inward slope. The reasons underlining such a rational are not difficult to explain. First, the opening up of the interior profile of a window allows sunlight to scan a certain position within the church for a longer period of time and expand its reach within the interior



areas (Same principle, but in reverse, of the embrasure in a castle wall). Second, beveling the window reveals and window sill inward creates the effect of offering the eye a significant area of transition between the strong direct sunlight and the relatively dim interior. Third in the case of an outward sloping sill placed before the glazing, the light is reflected upward toward the quarter-sphere of the apse or the dome. Thus, the window sill serves as a reflective surface which furnishes diffuse light to the usually important iconographic representation at the conch (quarter-sphere) of the ceiling above. Fourth, the necessary confluence of reflected and direct light occurs at the very point where light is admitted to create the desired light shafts that illuminate selected zones of the church interior.

Examples of Light Manipulation in the Apse

The reception of light onto the altar at a particular time and day seems to have always been a desired effect. However, the manner and timing of its occurrence appears to have varied in different periods and locales.

Old St. Peter's Basilica, Rome

Lethaby and Swainson, agree that fourth century churches usually had the sanctuary placed toward the west (Fig. 5.34, 5.35).⁵²

... the Basilica of St. Peter itself was exactly orientated, but, of course, as in all the old Basilica churches, the Tribune and High Altar were at the west end, the latter having its back towards the congregation, so that when celebrating the priest and the congregation faced each other. So exactly due east and west was the Basilica that, on the vernal equinox, the great doors of the porch of the quadriportious were thrown open at sunrise, and also the eastern doors of the church itself, and as the sun rose, its rays passed through the outer doors, then through the inner doors, and penetrating straight through the nave, illuminated the High Altar.⁵³

Hagia Sophia, Istanbul

Since Hagia Sophia represents one of the greatest examples of Byzantine architecture one can reasonably expect it either to have initiated or to have kept and improved upon important traditions and design principles. This does not imply, however, that later churches could and would have necessarily followed in the footsteps of this unique example. Any similarities in concept and intention would only indicate the powerful and lasting impact of church canon and religious ritual on the design.

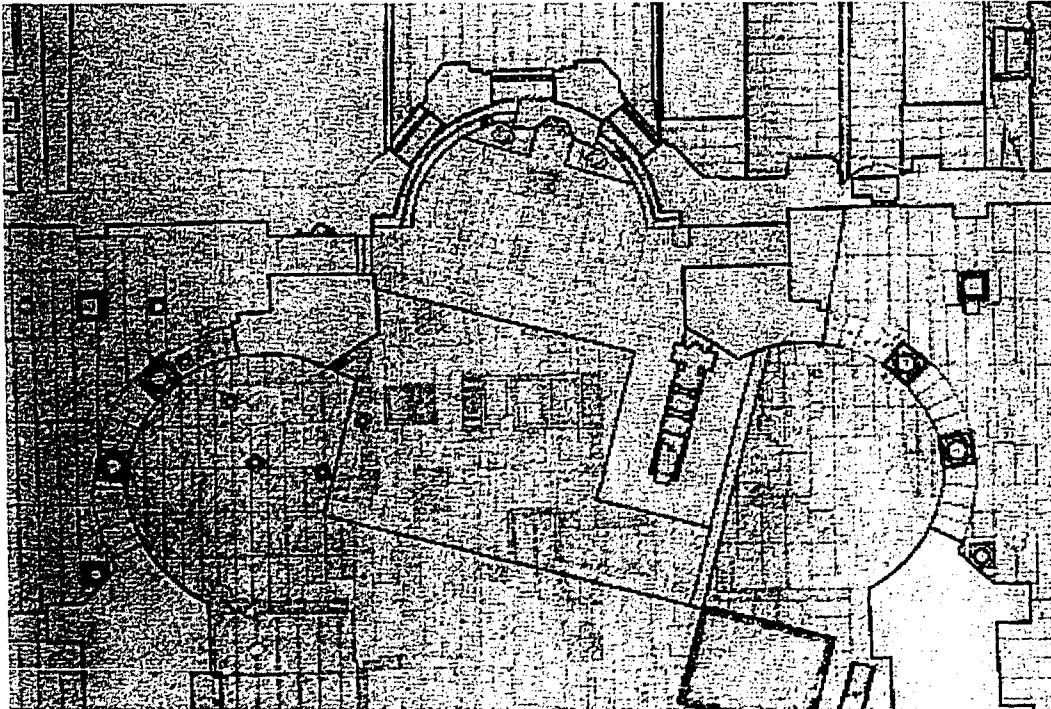


Fig 5.37 Plan at Ground level by Van Nice. Hagia Sophia, Istanbul.

The system of orientation described in this dissertation is substantiated by the orientation of Hagia Sophia with impressive precision.⁵⁴ However, Hagia Sophia is not unique in this respect. A similar sharp turning of the main axis to the south of east had been employed in many earlier and later churches (Fig. 5.36).⁵⁵ This indicates that the turning of the axis may have followed certain principles established at least since the fifth and perhaps as early as the end of the fourth century. The longitudinal axis of Hagia Sophia is turned exactly toward the sun azimuth of the *third hour* of the equinox which is also close to the sun azimuth of the *third hour* of the 17th of September in 532 A.D. (date of the celebration of Hagia Sophia) the year of the beginning of the church construction (Fig.5.37).⁵⁶ This means that a shaft of light would shine on the altar of this church on the *third hour* of the equinox through the central lower window of the main apse as well as on the date of the celebration of Hagia Sophia. Shafts of sunlight would be received in the altar, in the winter and summer solstices, as well as on many other dates.

These light shafts would have been unobstructed and visible to the congregation because at that time there was no full-height solid barrier screen similar to the iconostasis found today in Greek and Russian churches which became common after the twelfth century.⁵⁷ The altar was set behind the chancel screen but it was not hidden by it because it took the form of a low parapet set between taller, free-standing columns which carried an architrave at a higher level, similar to that of Sta. Maria in Cosmedin at Rome or to those of the basilicas A and B in Theba, Greece (Fig.5.38, 5.39).⁵⁸ The original altar location in Hagia Sophia is not exactly known but scholars tend to agree that it must have been located behind the screening columns of the chancel screen on axis at the middle of the *bema*, slightly in front of the two eastern secondary piers and placed on a stepped platform with an elaborate ciborium or canopy above it.⁵⁹

For the purpose of our study the height of the upper surface of the altar is placed approximately at two meters above the level of the present floor at the location indicated by Mainstone (Figure 5.40),⁶⁰ while the apse windows sizes and locations used are those

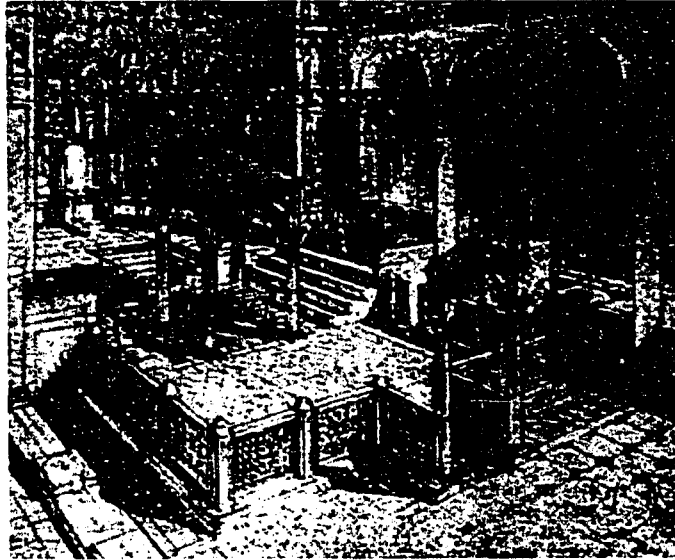


Fig.5.38 Reconstruction of chancel screen Basilica A. Thebe, Greece.

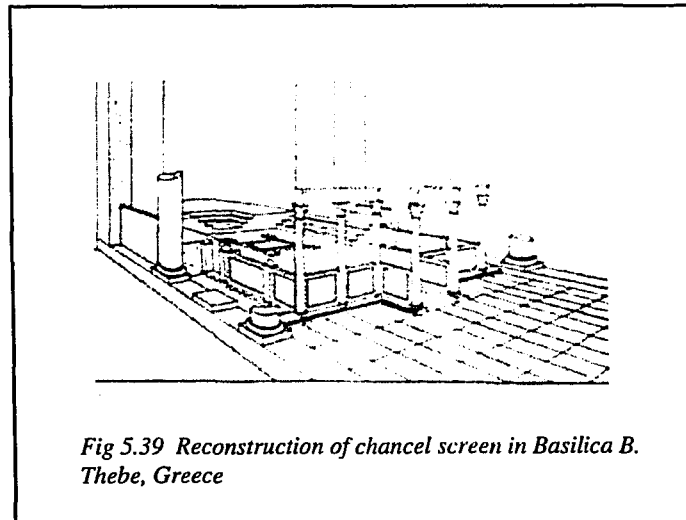


Fig 5.39 Reconstruction of chancel screen in Basilica B. Thebe, Greece

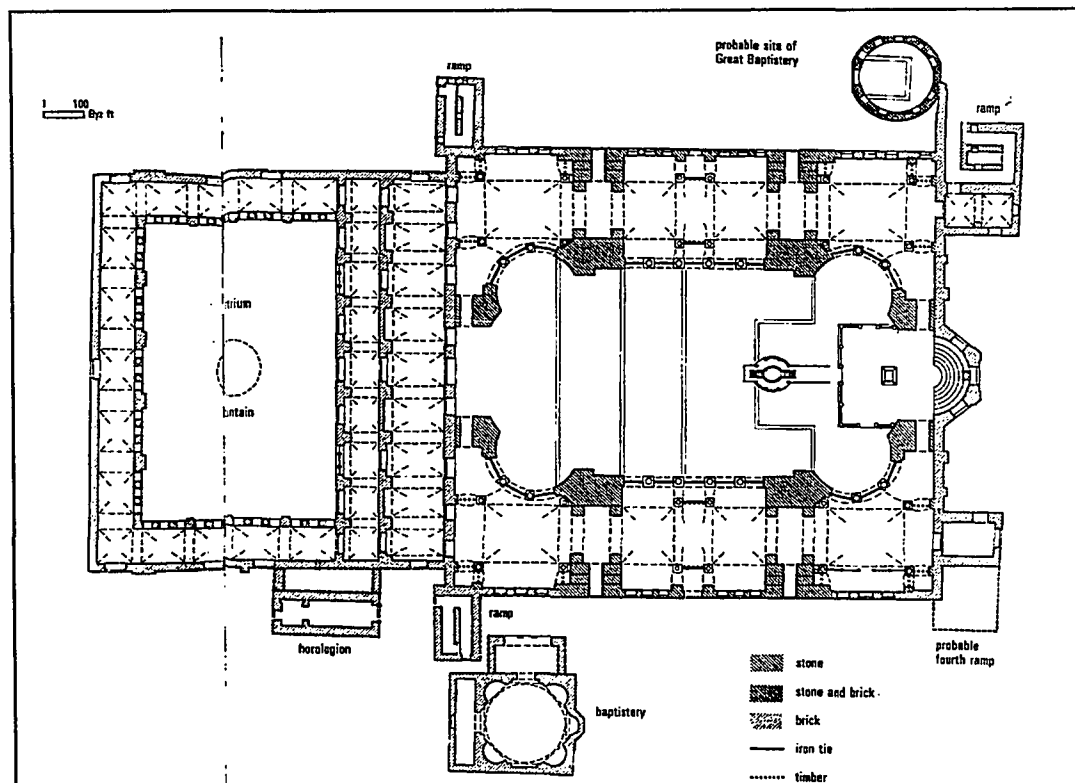


Fig.5.40 Hagia Sophia Istanbul. Plan.

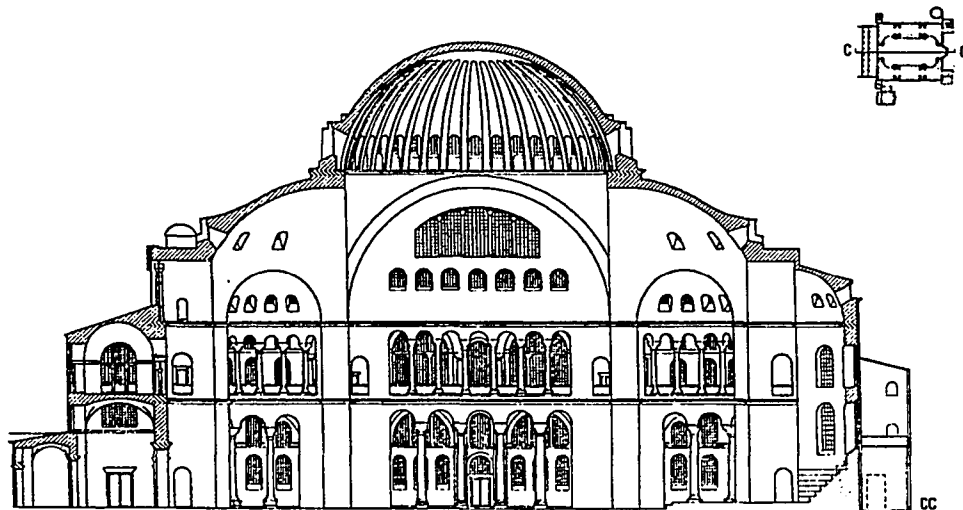


Fig. 5.41 Hagia Sophia, Istanbul. Section.

surveyed by Robert Van Nice (Fig. 5.37). The sun angles were calculated for the mid-point of the side of the altar facing the congregation because this is the location on which the priest stands when raising the Holy Sacraments.⁶¹ The sun is aligned on axis with the altar through the central lower window of the apse on the *third hour*. The sun in its sweeping motion bathes this location with a shaft of light for some time.⁶² Examining the alignment of the sun with the location of the altar in the winter solstice we find again that the sun reaches the altar. The first consecration of the church took place on 27 December 27th 537 and the second on December 24th 562.⁶³ During that day a shaft would have also been cast on the altar through the southernmost window. In June 21st, which is the summer solstice the sun aligns on the *third hour* through the upper northernmost window of the apse. The northernmost and southernmost windows of the apse are not aligned on center with the summer and winter solstices. The northernmost window, however, is aligned on center with the celebration of Constantine and Helen on May 21st and it accommodates all possible dates for Pentecost.⁶⁴ The southernmost window is aligned with Nov. 21st the celebration of Mary's Entry in to the Temple.⁶⁵

The time schedule was observed during the liturgy in Hagia Sophia with utmost exactness a fact which is evidenced by the existence of a separate structure devoted to time measurement which was often consulted by the priest; the so-called *Horologium* (clock).

According to Theophanes the *horologium of the Milium* was erected near the church by Justinian shortly before the latter itself was completed.⁶⁶ This frequently mentioned "time-measure" seems to have been a semi-independent structure of some importance, set within a court of its own, fronting the baptistery and adjoining the church on the southwest.⁶⁷ To this court opened the southern vestibule of the narthex, its outer doorway hence known as the Gate of the Horologium.⁶⁸ That the Horologium was provided not only with sundials and clepsydra but also, perhaps, with a mechanical clock seems probable, since timepieces of the type are mentioned as early as the tenth century and it has been conjectured that they may well have been invented at a considerably earlier date.⁶⁹ The traditional location of the Horologium was preserved by the erection of Turkish sundials in this same general region.⁷⁰

The southern vestibule is entered from the south through a porticoed

gateway, known as the Gate of the Horologium because it opened on a small court between the Baptistry on the east and the Horologium on the west. The latter, now missing, is known to have been situated near the southwestern angle of the church.⁷¹

St. Irene, Istanbul

Hagia Eirene was built in 326 A.D. and was remodeled during the time of Justinian. Its main axis is turned toward the south of East by 37° - $40'$.⁷² This is 127° - $40'$ from true North. The day of the celebration of St. Irene, according to the Byzantine church calendar, is on May 5th (Appendix 2) the sun aligns with the altar exactly through the center of the northernmost window of the apse. The sun aligns with the altar through the central window from its northernmost edge on the equinox (Fig. A1.11, A1.12, A1.13).

St Andrew en Krisei, Istanbul

The church held the remains of the iconodule St. Andrew of Crete.⁷³ The church stood on the Seventh Hill of the city already in the 6th century. It was embellished and restored and received the remains of St. Arsenius by Theodora.⁷⁴ The church has a single window in the apse. The leftmost reveal of the apse window allows the sun to align with the altar just on midmorning of the Saint's nameday for about one hour and forty minutes (Fig. A1.14).

St. Theodosia, Istanbul

The church is turned toward the south of east by 40.5° which aligns it with 130.5° azimuth from North. It only has two windows in the apse. In midmorning on May 29th of 550 AD (St. Theodosia's feast) the sun aligns with the altar through the left edge of the northernmost window (Fig. A1.15).

St. Peter and Mark, Istanbul

The northernmost window accommodates the date April 25th for St. Mark and the southernmost the date January 16th for St. Peter while the left edge of the central window is turned toward the equinox (Fig. A1.17). Note the peculiar spacing of the windows in the apse (section) in order to accommodate the angles. It also accommodates the date of

29th of June (St. Peter and Paul's).

St. Thekla, Istanbul

The axis is oriented at an azimuth of 117° . There is a bilobe window in the apse and the single column is aligned with the axis. In mid-morning of St. Thekla nameday on the 24th of September (6th c), the sun enters just to the right of the central column and it disappears, half-hour later ⁷⁵ (Fig. A1.16)

St. Demetrios, Thessaloniki

The church of St. Demetrios was built in the 5th century. It is turned toward the south of east being 123° from North. This corresponds to the midmorning of equinox. (Fig. A1.18, A1.19)

H. Sophia, Acheiropoietos, Rotonda, Thessaloniki

Other churches such as Hagia Sophia, Acheiropoietos, and Rotonda (st. George) of Thessaloniki all of which are large cathedrals are turned toward the midmorning of the equinox. (Fig. A1.20, A1.21, A1.22, A1.23).

H. Apostoloi, Thessaloniki

The church of Hagioi Apostoloi in Thessaloniki, originally dedicated to the Virgin is turned toward the day of the celebration of Mary's Dormition (Fig. A1.24, A1.25). The church axis is oriented at 112° from N, so that the left most reveal of the central window aligns with the altar on that day.

Megiste Lavra Monastery, Mount Athos

The axis of the Katholikon of Megistes Lavras is 97° from true North. The sun aligns with the altar through the edge of the central window at 93.2° from North. This angle corresponds to the date of the celebration of St. Athanasius the Athonite (July 5th) who was the founder of the monastery. The sun aligns with the altar through the left edge of the southernmost window on March 25th (St. Mary's Annunciation) (A1.10).

Dionysiou Monastery, Mount Athos.

The axis of the Katholikon is oriented at 127° from North. ⁷⁶ On the day of the

Nativity of St. John the Baptist (June 24th) the sun aligns with the altar through the northern most window at 92.5° from North. Also, the sun is aligned with the altar through the leftmost reveal of the central window on the day of the equinox (Fig. A1.26).

For additional examples see Appendix 3.

Other Light Effects

In the church design it is possible that the form, the openings, and the orientation of the dome were composed so as to allow distinct shafts of light to scan the building interior.

Phenomena involving natural light calculated to create a particular impression have been observed by various scholars but no attempt has been made to investigate the lighting design as a systematic and coherent effort. Certain devices related to light, other than the effects previously described here, have been discovered in Hagia Sophia designed to impress the visitor. Gervase Mathew notes:

The careful placing of mosaic tessellae on squinches and pendentives, in cupolas and vaults was influenced by optical theory. Even on plain surfaces it became the custom to curve the setting bed in order to deflect the light. Although the deviations from the vertical and the undulations in surface measurement are commonly very slight they seem too carefully contrived to be anything except deliberate. An example may be given from personal experience. There is evidence for three stages in the preparation of the mosaic of the Mother and Child in the vestibule of Hagia Sophia. (Fig. 5.42) . . . The intricate measuring and angling of this mosaic are best explained if it was intended to be seen at thirteen meters from its centre at man's height from the floor.⁷⁷

Another discovery was made along the same lines by Thomas Whittemore in his work on the mosaics of Hagia Sophia. In his detailed report of the mosaics in the narthex he writes:

The field of each lunette is slightly concave and the gold tessellae are set into it not vertically, but with their faces inclined at a slight angle. It is certain that this irregularity was not adopted in order to economize material - there was no parsimony here; it seems rather that, as far as this deflexion was intentional, the aim was to secure a sparkling movement of light and a play of colour that should suggest atmosphere and even ensure for the crosses some appearance of solidity or relief. No regularity was



Fig. 5.42 Mother and Child Vestibule mosaic. H. Sophia, Istanbul.

noticeable in the angle of the inclination of the tessellae to the vertical plane; they are set more vertically in Lunette F, less vertically in Lunette C, and the angle is more pronounced in Lunettes A and B. The exact slope was sometimes fortuitous. It was certainly sometimes increased, and in some instances it was produced, less by a conspicuous purpose to create glitter and liveliness in the mosaic fields than by the shrinkage of plaster during hardening. It is known that plasters used in the construction of Hagia Sophia were prepared with different ingredients and that material used for the preparation was of diverse origins. One effect of these variations was to produce distinct degrees of contraction and to bring as a consequence visibly different tilting of the tessellae.⁷⁸ (Fig. 5.43, 5.44, 5.45, 5.46).

No photograph can convey the power of the appeal of this succession of images. They constitute no trivial repetition of a single shape; but each meets the vision as if charioted on a billow of light, each with an appeal as thrilling, and compelling, and personal, as it seems possible to experience. The effect as you move past them has the cumulative power of a rising flood, and they engulf you in the religious enthusiasm of Byzantine conviction.⁷⁹

Whittemore commented also on the quantity of light of the mosaic of Christ as

Gate in the central lunette of the narthex of Hagia Sophia:

The impression we win from the play of light on the accented surface is that of the hazy gleam of summer air grazing the stream of the Bosphorus. (Fig. 5.47).⁸⁰

Another effect identified from personal observation is that the illumination of certain frescoes on the walls of the nave coincided with the recitation of related parts of the scriptures. For instance, during Vespers in the Katholikon of Os. Gregoriou light fell



Fig. 5.43 H. Sophia, Istanbul. Ornamental cross.

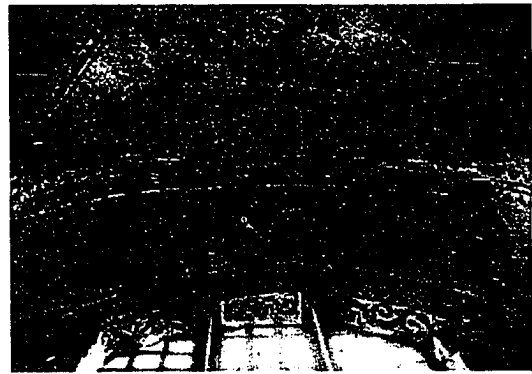


Fig. 5.44 H. Sophia, Istanbul. Ornamental cross.

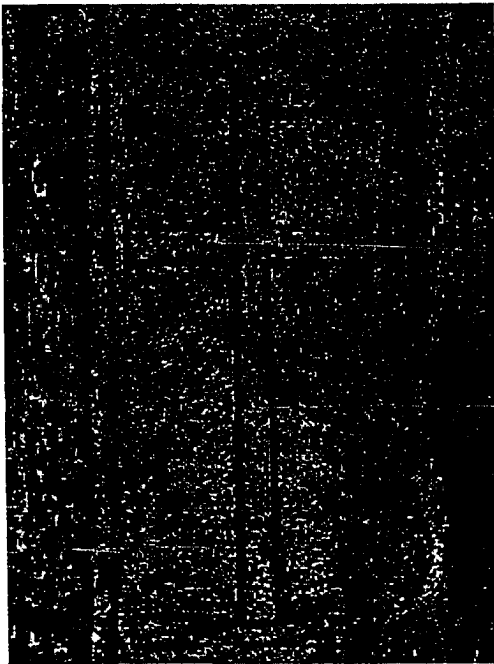


Fig. 5.45 H. Sophia, Istanbul. Ornamental cross.

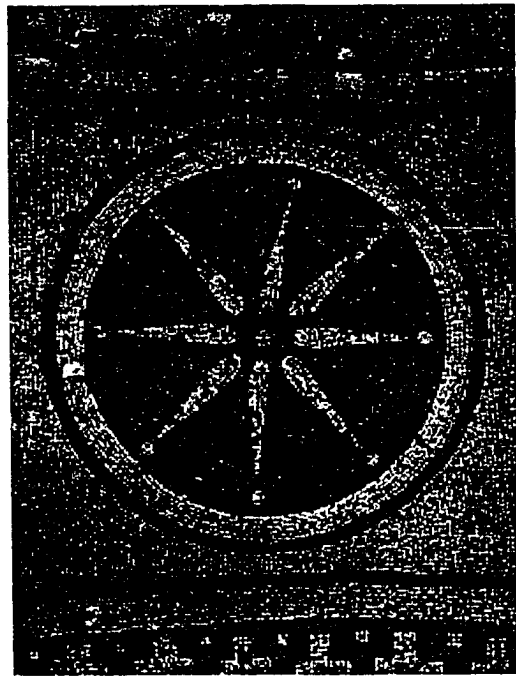


Fig. 5.46 H. Sophia, Istanbul. Ornamental cross.

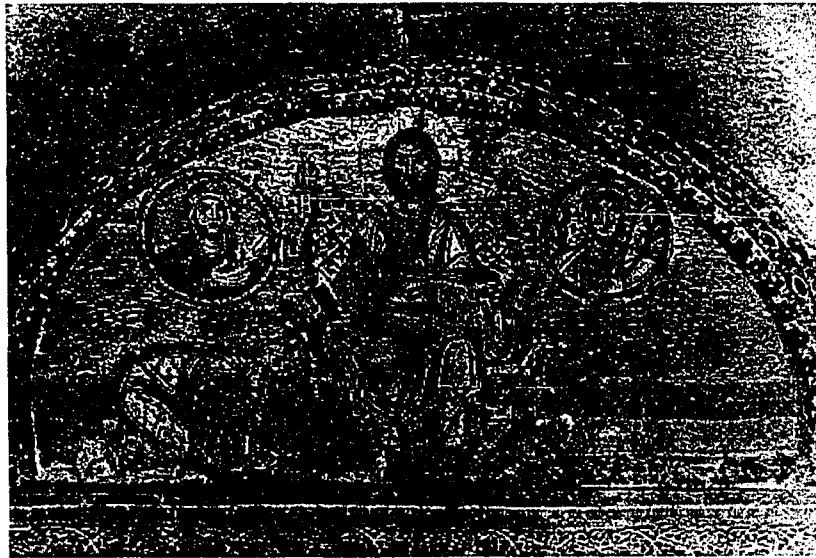


Fig. 5.47 Jesus as Gate, "I am the light of the world...". H. Sophia, Istanbul.

on the image of Matthew, located on one of the pendentives of the main dome, while a part of his Gospel was read. This effect has been referred to earlier as the effect of the "roofed spherical dial." However, in order to examine the degree to which these were designed effects in many Byzantine churches sophisticated equipment and a concerted team effort will be necessary. Also the precise timing of the various parts of the liturgy will have to be documented for the historical periods in which the churches were built. This effort far exceeds, however, the purpose and the scope of the present work.

Notes to Chapter V

¹ Vischer, Aesthetik III, "Aussenbau and Innenbau." cited in Michelis, An Aesthetic Approach to Byzantine Art: 30-33.

² Marinos Kalligas, He Aistheteke tou Chorou tes Hellenikes Ekklesias sto Mesaiona [The Aesthetics of Space of the Greek Church in the Middle Ages] (Athens 1946): 23 note 1.

³ Kalligas, He Aistheteke tou Chorou tes Hellenikes Ekklesias: 44-5. Procopius, De Aedificiis trans. A. Stewart: 176, Paul the Silentarius, "Ekphrases" in Lethaby and Swainson : 407-409

⁴ The gate between the narthex and the nave.

⁵ The forehall preceding the nave.

⁶ Kalligas, He Aistheteke tou Chorou tes Hellenikes Ekklesias: 24-25; also Georgios Soteriou, Christianiki kai Vyzantini Archaeologia [Christian and Byzantine Archaeology] (Athens 1942): 200-205.

⁷ Kalligas, He Aistheteke tou Chorou tes Hellenikes Ekklesias: 26, 27 n. 2

⁸ Kalligas notes that in later periods, in more provincial and smaller churches, one might not be able to see exactly the apex of the dome when being at the edge of the nave; one's glance, however, would reach very close to the area of the apex. This course applied to most churches he had observed. It appeared to be something essential and fundamental to Byzantine medieval architecture. Ibid.: 26-27 and 27 notes 1, 2.

⁹ Ibid.: 27

¹⁰ Ibid.: 28

¹¹ The catechoumens were those who were being instructed in the faith and had not yet been baptized.

¹² Those who were sinners and by ecclesiastical verdict were not allowed to enter the nave. Ibid.: 23

¹³ John 3, 20-21 cited in Kalligas, He Aistheteke tou Chorou tes Hellenikes Ekklesias: 31.

¹⁴ Patrologia Graeca 155:337-340, 360

¹⁵ Kalligas, He Aistheteke tou Chorou tes Hellenikes Ekklesias: 21 note 2

¹⁶ Ibid.: 28-29, and 29 notes 2, 3, 4. Other expressions found in Agapios Theotokarion (Venice, 1780) are: "cloud full of light, fiery column of light, gate of light,

intelligible ladder from earth to heaven, Lord, my enlightenment and savior":9ff.

¹⁷ Kalligas, He Aistheteke tou Chorou tes Hellenikes Ekklesias: 30, and 30 note 1. Also see Gedeon Agiotafitou, Vios Eniausios [Perpetual Life] (Lipsia, 1761): 1495.

¹⁸ Kalligas, He Aistheteke tou Chorou tes Hellenikes Ekklesias: 30 note 1.

¹⁹ Ibid.:31-32, "I send you to them so that you open their eyes, and bring them back from darkness toward light and from satan to God." (Acts, 26, 16) cited in Ibid.: 32 note 1

²⁰ Ibid.: 32-33. Also see citations in p.33 note 1. A.Schmarsow, Grundbegriffe der Kunstwissenschaft (Leipzig, Berlin, 1905): 41-43. K. Gross, "Das Ästhetische Miterleben," Zeitschrift für Aesthetik, IV (1900): 161ff. Theodor Lipps, Aesthetik v.2 (Leipzig, 1920): 414ff.

²¹ "Parakletika tes Theotokou," [Supplicatory of the Virgin Mary] Orologion : 447 cited in Kalligas, He Aistheteke tou Chorou tes Hellenikes Ekklesias: 43-4.

²² Krautheimer, Early Christian and Byzantine Architecture: 202-203.

²³ Michelis An Aesthetic Approach to Byzantine Art: 38, 39.

²⁴ Ibid.: 39, 40

²⁵ Ibid.: 40

²⁶ The dome was also considered as an aperture through which the Lord looked on the faithful on earth.

²⁷ Ibid.: 105-106

²⁸ The ideas presented in Kalligas' book were based on the observations of Hagia Sophia of Thessaloniki during Easter of 1933. These were composed into a dissertation Kalligas, Die Hagia Sophia von Thessalonike (Wurzburg 1935). See Kalligas, He Aistheteke tou Chorou tes Hellenikes Ekklesias: 7.

²⁹ Excerpts of psalms and readings with references to light in regular use in modern liturgy are found in the remarkable work by the well known architect and Byzantinist Kalligas, Ibid.

³⁰ John 8, 12 cited in Ibid.: 30, note. Also see figure in O.M. Dalton, Byzantine Art and Archaeology (Oxford, 1911): 409.

³¹ Michelis, An Aesthetic Approach to Byzantine Art: 93-94

³² In the early Christian churches, generally, light was always profuse, but as time went on it was subdued more and more until, in the post-Byzantine church, space sinks into a permanent twilight.

³³ Mango in Mark and Cacamak, Hagia Sophia from the Age of Justinian to the Present: 43-44.

34 Procopius, De Aedificiis transl. A.Stewart : 6.

35 Light in Hagia Sophia was more abundant before the large windows in the side screen-walls were replaced by the present numerous small windows. Several small ones in the large niches have also been blocked. See Michelis, Hagia Sophia, (Athens, 1946); and Swift, Hagia Sophia, (New York, 1940).

36 John Warren, Greek Mathematics and the Architects to Justinian (London: Coach Publishing, Art and Archaeology Research Papers, Dec. 1976)

37 Schlumberger, L'Epopée byzantine: II, 38; Strzygowski, Origin of Christian Art: 62; Swift, Hagia Sophia: 153.

38 Agathias, Historiae: 295. Theophanes, Chronographia: I, 360, also Malalas, Chronographia: 490, and Cedrenus, Synopsis Historiae: I, 677, also Swift, Hagia Sophia: 153. Zonaras, Epitome Historiarum: III, 282-283. Anonymous of Banduri, Vol. I, Lib. IV:78; Codinus, De Aedificazione Sanctae Sophiae:144; Glycas, Annales: 507.

39 Mainstone, Hagia Sophia: 127.

40 Procopius, De Aedificiis transl. A. Stewart: 10.

41 See section on Other Light Effects in this chapter.

42 Kenneth Connant, "The First Dome of St. Sophia and Its Rebuilding," American Journal of Archaeology XLIII (1939): 589, also Bulletin of the Byzantine Institute (1946): 71-78.

43 An investigation begun in 1994 employed computer modeling to examine the dome forms proposed by the various theories in respect to light. However, this investigation being lengthy and involving considerable expense, is still far from being complete. The examination is conducted on the basis of a computer simulation of a three-dimensional model of the dome, incorporating the reflector described by Anthemius. The computer model constructed so far adopts the form of the original dome proposed by Kenneth Conant (Fig. A1.). Ibid.: 71-78. But this investigation has encountered two problems. First, it thus far has not been possible to find a computer program capable of simulating the actual movement of light in space. Hence, while the computer images generated correspond to the actual form of the original dome, as projected by Conant, the way that light appears to be captured by the dome is incorrect (Fig. A1. ,). Second, the importance of the circular opening (concentric around B in Fig.4.20) was only subsequently realized, and this had not been incorporated in the initial simulation. This means that the present shape of the reflector and the form of the opening must be revised.

44 Robert L. Van Nice, Saint Sophia in Istanbul. An Architectural Survey Installment 1 and 2 (TheDumbarton Oaks Center for Byzantine Studies, 1965).

45 George G. Scott, An Essay on the History of English Church Architecture (London: Simpkin, Marshall and Co., M:DCCC:LXXXIX): 14

46 Other churches whose main axis is turned sharply toward the south of east are Hagia Eirene in Constantinople, San Vitale in Ravenna, and the church of the monastery of Constantine Lips in Constantinople.

⁴⁷ E. H. Swift, Hagia Sophia (New York: Columbia University Press, 1940):18-9.

⁴⁸ M. Minnaert, The Nature of Light and Colour in the Open Air (New York: Dover 1954): 50-54.

⁴⁹ Window glazing from a church found in a 11th century monastery in northern Greece was of golden, tinted translucent glass. Ch. Bakirtzes, Spring Byzantine Studies Symposium 1993, Birmingham, England. According to Krautheimer, glass panes in Hagia Sophia were presumably colored like those found at San Vitale, deep blue, greenish, dark purplish brown, off white, yellow, light purple. C. Cecchelli, Felix Ravenna, N.S. 35 (1930):1ff. cited in Krautheimer, Early Christian and Byzantine Architecture: 216. Silentiarius refers to "window openings made in the apse through which streams the splendor of the golden morning light." Silentiarius in Lethaby and Swainson, The Church of Sancta Sophia: 42. Michelis maintains that the Byzantine church used polychrome surfaces and translucent windows, that lent light magic tones which enriched and animated the interior space. When this kind of glass was substituted by clear glass the Byzantine churches lost much of their mysterious atmosphere. Michelis, An Aesthetic Approach to Byzantine Art (London: B.T. Batsford Ltd 1966): 91-93.

⁵⁰ Kalligas, He Aistheteke tou Chorou tes Hellenikes Ekklesias: 47, Antoniades, Eugenios Michael Ekphrasis tes Hagias Sophias 1907-1909 (Athenai: V. Gregoriades & Huioi, 1983) v.3, table 96:122

⁵¹ "Diegesis" edited by T. Praeger, Scriptores Originum Constantinopolitanarum (Leipzig, 1902), 1: 74-108 cited in Mango in Mark and Cacmak, Hagia Sophia: 47.

⁵² Lethaby and Swainson, The Church of Sancta Sophia: 17-18, cited by Swift, Hagia Sophia: 8

⁵³ H.W. Brewer, "Old St. Peter's, Rome," The Builder (Jan. 2, 1892): 4

⁵⁴ Attempts to explain the orientation of Hagia Sophia to this day by various scholars have not proven satisfactory. I include here Swift's discussion of its orientation:

"The main axis of the church is not on a line due East and West, but inclines 33.4 ° to the south of east (Antoniadi, I, 73). Various theories have been advanced at different times to account for this anomaly, all of them unsatisfactory. We may discard at once the suggestion that the axis was so laid as to point toward Jerusalem. Labarte's theory, that the orientation was determined by the already existing structures of the palace, seems scarcely more credible, although it has been followed by the majority of writers on the subject. Schneider, "Die vorjustinianische Sophienkirche," in Byz. Zeitschr., XXXVI (1936): 78. That the church was so placed as to stand parallel with lesser buildings, themselves already in ruins, at least in part, as a result of the disastrous fire kindled during the Nika riots, appears highly improbable, more particularly in view of the outstanding importance of the new church itself. Labarte seeks to strengthen his case by asserting that the long axis of the Hippodrome and the major axis of Hagia Sophia, if extended, would form a right angle at their point of intersection. Le Palais Imperial de Constantinople et ses Abords: 17-8. If this were true, his theory might be plausible. As a matter of fact, however, the angle thus formed is obtuse and has a value of about 100° (Antoniades, I, 75). Starting with a suggestion of Lethaby and Swainson that the inclination of the main axis of the church whether by chance or intent, was turned

toward the winter solstice, (Lethaby and Swainson, Sancta Sophia: 17) Antoniadi advances the theory that the intention of the architects was to orient the church so that its axis might point directly toward the rising sun on the festival of the birth of Christ, to whom the church itself was dedicated, because to the Byzantines the Christmas sunrise symbolized the coming of Christ into the world. This view he supports by a number of quotations. Procopius says that "the face of the church was towards the rising sun in order to celebrate the mysteries in honor of God"; (Procopius De Aedificiis:175) and according to the patriarch Germanus, writing in 720, "the custom of praying toward the east is enjoined, as the rest also, by the holy Apostles, and is thus because of the fact that the intelligible sun of justice, Christ our Lord, appeared upon earth in the regions of the rising of the sensible sun, in accordance with the word of the prophet which says 'Orient is his name' "(Historia Ecclesiastica; Migne, Patrologia Graeca, IIC, 392.). Antoniadi asserts that, during the reign of Justinian, the center of the sun, when fully risen above the marine horizon, would stand on Christmas Day at a point 31° 41' to the south of east. But since the eastern horizon, as seen from Constantinople, is bounded by the mountains of Bithynia, the center of the sun, fully risen above the hills, would be found on Christmas to stand somewhat south of this point, yet still slightly north of the spot on the horizon to which the major axis points (Antoniadi:loc.cit.). If the orientation of Hagia Sophia is to be explained according to this theory, Antoniadi must admit that one of the greatest architectural engineers in history made an error of about 1° 40' in laying out his masterpiece (Antoniadi claims (I,76) that the orientation of the majority of Byzantine churches agrees with his theory for Hagia Sophia)." Swift, Hagia Sophia: 18-9.

⁵⁵ The Constantinian Hagia Sophia had the same orientation as the Justinian Ibid.

⁵⁶ Robert Van Nice measured the Hagia Sophia axis as turned toward the south of east by 33.4° (123.4° from North) Robert Van Nice . . . I have measured it as 33.7° or 33.8°. See Appendix 3.

⁵⁷ Kalligas, He Aistheteke tou Chorou tes Hellenikes Ekklesias: 25 note, and Soteriou, Hristianike kai Vyzantine Arhaeologia A' (Athenai, 1942): 200-205.

⁵⁸ Mainstone, Hagia Sophia: 221-222.

⁵⁹ The altar position is illustrated in in Mainstone, Hagia Sophia: 214, Figs. 241, 252. Anonymous in Banduri, vol.I, Lib. IV, p.74 A. Imperium Orientale. sive Antiquitates Constantinopolitanae (Paris, 1711) in Corpus Byzantinae Historiae vol. XXV, I. Mainstone, Hagia Sophia: 222. The second altar set up by Justinian in 563, was of great size and dazzling magnificence. Rogers de Clari gives its length as 14 ft., about 4.50 m. Hopf K., Chroniques Gréco-Romanes (Berlin, 1873), op. cit., p.67. in E. H. Swift, Hagia Sophia : 193

⁶⁰ To account for the height of the stepped platform which no longer exists.

⁶¹ So the area which would be most significant to be lit is from the surface of the altar and above including the height of a person with raised hands, that is, from about 2 - 4.20 m from the present floor.

⁶² To be exact, considering the speed of the sun's motion in the sky and the width and height of the central window, direct sunlight remains at that point for 50 minutes, from 8:30 (alt/az=27/117)- 9:20am(alt/az=35/128). This duration is somewhat reduced when the full height of the priest with raised hands is taken into account.

⁶³ Lethaby and Swainson, Sancta Sophia: 29.

⁶⁴ That May 21st was a very important date and that it was celebrated in Hagia Sophia is evidenced by the narration of a miracle that had taken place in this church on that day involving artificial light and the Holy Spirit. Silentiarius in Lethaby and Swainson, Sancta Sophia:105.

⁶⁵ Table 2. For important dates of mass celebration in Hagia Sophia see Downey, Constantinople:116

⁶⁶ Theophanes, Chronographia I:478.

⁶⁷ Banduri, Lib. IV:68-70.

⁶⁸ Porphyrogenitus, De Ceremoniis I, 63, 156.

⁶⁹ Antoniadès, Ekphrasis :120-121.

⁷⁰ Ibid., I, 120, 122. Swift, Hagia Sophia: 180; Mainstone, Hagia Sophia:
110

⁷¹ Ebersolt, Saint-Sophie de Constantinople: 2; Swift, Hagia Sophia: 94.

⁷² Walter S. George, The Church of St. Eirene at Constantinople (London: Oxford University Press, 1912): 9

⁷³ Alexander Van Millingen, Byzantine Churches in Constantinople: Their History and Architecture (London: Macmillan and Co. Lim., 1912): 113-7 also Diehl, Manuel de l'Art Byzantin (Paris, 1910): 74 Fig.26.

⁷⁴ Van Millingen, Byzantine Churches in Constantinople: 108, 110-11.

⁷⁵ Information in Van Millingen, Byzantine Churches in Constantinople: 206; Downey, Constantinople: 94.

⁷⁶ Measurements by "Kentro Ereunas kai Diafilaxis Agioreitikis Klironomias" (K.E.D.A.K) [Center for the Research and Keeping of the Mount Athos Heritage]

⁷⁷ Mathew, Byzantine Aesthetics: 29. For the lunette of the Hagia Sophia vestibule of South end of narthex see American Journal of Archaeology XLII (1938), 95-6, 226.

⁷⁸ Thomas Whittemore, The Mosaics of St. Sophia at Istanbul. Preliminary Report on the First Year's Work, 1931-32. The Mosaics of the Narthex, v.1 (Paris: Oxford University Press for the Byzantine Institute, 1933): 14

⁷⁹ Ibid.: 12.

⁸⁰ Ibid.: 22.

CONCLUSIONS

This dissertation began as much a personal search as a scholarly endeavor. It was initiated at first by certain personal experiences acquired at a young age, kindled by the exquisite atmosphere found in Byzantine churches, an atmosphere that in my view has never been equaled in modern ones. Throughout my architectural studies, it became increasingly apparent that this kind of atmosphere was not solely related to architectural form, but rather encompassed some sort of an intangible quality that seemed to emerge in its own right as a consequence of some ethereal manipulation of light. More and more I felt the need to inquire into the conceptual as well as physical underpinnings of this quality, which seemed to exert a lasting impact upon anyone visiting these churches, for the ultimate purpose of making such an approach in some way part of my own designs. Initially, it appeared to me that the atmosphere pervading Byzantine church interiors has somehow been defined by its history, by the patina of time, by its being lived in and acted upon by generations of people-in short, by aspects that were intangible or that could not possibly have been designed. In time, however, I became aware of certain facts which indicated that at least some of these aspects had a clear physical explanation which could have been conceived and designed on purpose. This suspicion menacingly became a certainty as I began examining these structures with a more critical eye.

This critical attempt to seek out and define the basis, for creating this special atmosphere took concrete form in this dissertation, which set out to identify and investigate those aspects of the problem that could be stated, described, and shown to have constituted a clearly formulated set of principles followed by Byzantine architects and builders. In order to achieve this goal the investigation had to extend to areas outside of architecture; to fathom that ambience within which this architecture occurred and which served to engender its guiding conception. Hence, it became necessary to examine the

philosophical and religious mindset of Byzantine state and society which gave rise to such undertakings.

The outcome of this research clearly revealed that the church building was in fact designed to heighten the experiential impact of the Byzantine, and Late Orthodox, religious teachings and that light was actively employed and consciously manipulated as one of the most powerful and appropriate agents toward this end. This study established that light was thought to constitute the most essential quality of divinity by most Christian religious writers, beginning with the Old and the New Testaments and spanning the entire history of Byzantine civilization.

This dissertation also found that the traditions, both scientific and architectural, of pagan antiquity handed down to the Byzantines had a direct bearing on the manner in which Byzantine architects designed lighting effects. Too, Byzantine architects were exceptionally inventive and daring in designing and implementing their solutions. At the same time, the use of light and mirrors, while based on knowledge acquired throughout the Classical Greek and Hellenistic period appears to have been used not only in a more refined way, both architecturally and technically, but also in a profoundly more developed manner from a philosophical point of view. The aim seems to have been not to deceive the eye into believing in a mirage-like vision, but to use all the means in the Byzantine architect's disposal to offer the steps necessary to transport the faithful from perceptible reality to the realm of the noumenon. The use of lighting techniques were subtle and aimed at uplifting the individual above the everyday world; at offering a glimpse of the transcendent; at becoming a vehicle for apprehending a reality beyond space and time by means of guiding the senses, and through them the mind, in an upward directed motion aimed at projecting sudden visions of miraculous events and experiences that forms the basis of Orthodox dogma and religious beliefs.

The dissertation also added significant insight into the architectural use of light in Byzantine practice by examining the treatment of pictorial light in the art of the icon—

i.e.—the art most closely linked to the religious architecture of the Byzantine period. Frescoes and mosaics were found to employ significant canonically-rationalized concepts and techniques for rendering divine light, and those were shown to have direct equivalents in the architectural methods of manipulating and distributing light, in Byzantine church interiors. This is surely due to the fact that architecture was thought to constitute only a facet of a universal approach toward the arts under the auspices of a firmly founded Byzantine theology. Artistic expression was understood only within the confines of detailed dogma and corresponding laws of appropriateness which never exceeded its role of rendering perceptible in its essence the teachings of the Christ. Correspondingly, the dissertation established the existence of direct links, between Byzantine concepts and techniques for manipulating light and the meanings intended to be conveyed by the liturgy. These links were established first, in respect to the precise timing of the occurrence of specific lighting as related to the time keeping methods and calendar of the Byzantine period and second, in respect to relevant references to these in the scriptures and religious writings.

Case studies of several churches indicated that the selection of architectural forms and the modulation of openings were profoundly affected by if not directly determined, in response to the perceived need to receive and accommodate light in church interiors. Following this approach, the siting of Byzantine churches was directly linked not to the eastward orientation of the apse, but to the admission of light rays onto the altar on specific feast days and time of day. At the same time, despite the fact that this study was based on a small sampling of churches, its findings make clear that the whole Byzantine culture did not act in unison or reflect a consistency of practice. The orientation of each church, even though based on the same design principle, did not follow identical patterns precisely in the same way but tended to exhibit certain variations. Large cathedrals appear to have been oriented toward the equinoctial third hour, while smaller churches of more specialized use seem to have related more directly to the patron saint's nameday.

Also, the founders appear to have been recognized by the design of the openings in the apse. Elsewhere, in situations where two patron saints were commemorated by the same church, the apse openings seem to acknowledge both distinctively by the reception of light shafts onto the altar on the third hour of the feast day of each. Still, the incredible precision and absolute conviction that characterized Byzantine high art can only be sought in the highest and noblest examples, such as Hagia Sophia. The pattern, while it still persists, seems to lose its crispness and clarity as one examines lesser examples. Then, too, solutions that require daring beyond conventional norms, as was the case with the original dome of the Hagia Sophia in Constantinople, which was not only driven by a unique vision but also required a unique technical ability to carry it out successfully, cannot be expected to be repeated. In respect to the lighting effect of a radiant dome literary evidence was found that Anthemius, the most celebrated Byzantine architect, had devised a method which could allow him to achieve a perfectly illuminated dome in Hagia Sophia of Istanbul. Lesser church examples implemented less sophisticated solutions in order to achieve the same goal.

The methods for manipulating daylight in church interiors were known and handed down in handbooks. At the same time, new techniques were continuously being worked out as well. Not only did the interest, knowledge and focus of architects and scientists make this sophisticated design possible, but the will and drive of a religious culture possessed of unprecedented devotion provided both the inspiration and the material means that made the soil fertile for these designs to occur.

The importance of the principles guiding this singular approach, to manipulating daylight in church interiors however, is not a matter simply of archaeological interest. Rather, it provides us with a profoundly enriched view of architecture that expounds its humanistic potential. Space, light and time constitute some of the most powerful means of architectural expression that regrettably, are only occasionally employed in a conscious manner in our modern era.

APPENDIX 1

Drawings and Photographs of Selected Churches and of Hagia Sophia Computer Model

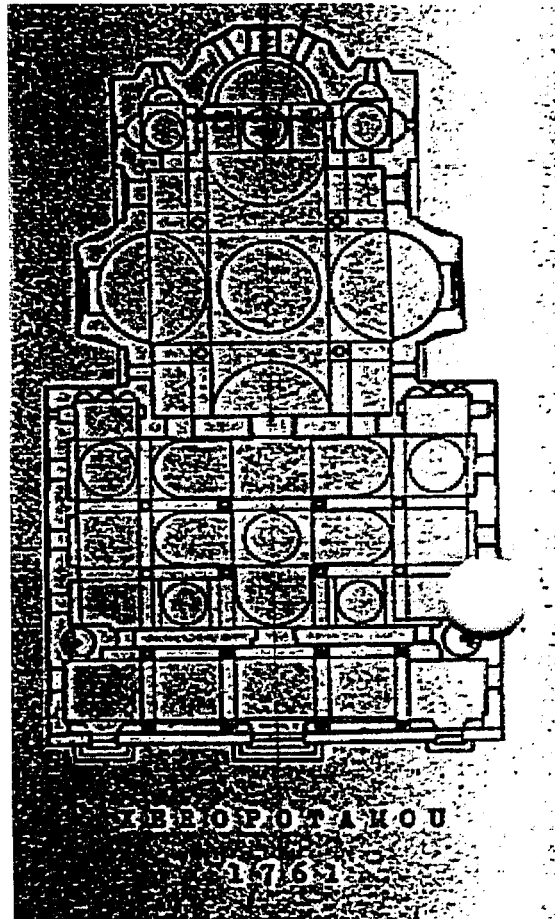
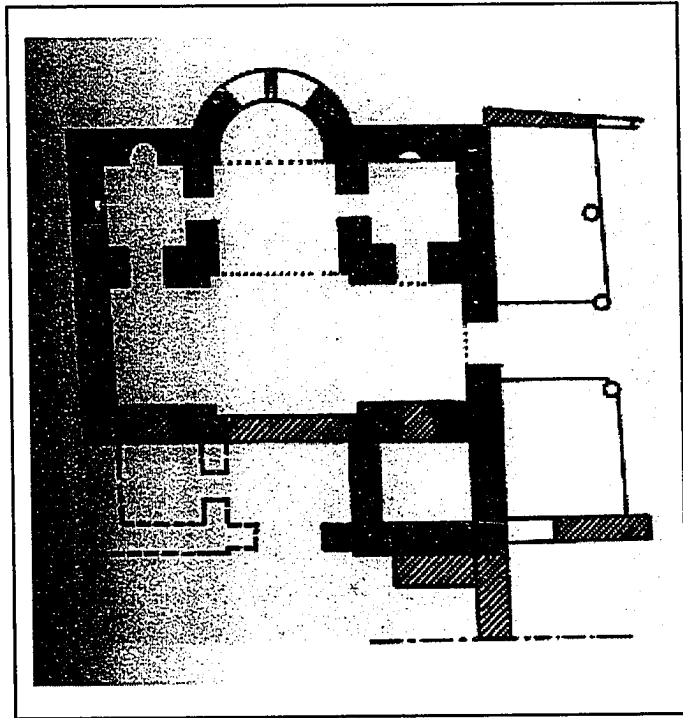


Fig. A1.1 M. Xeropotamou, Mount Athos



*Fig. A1.2 Osios
David, Thessaloniki*



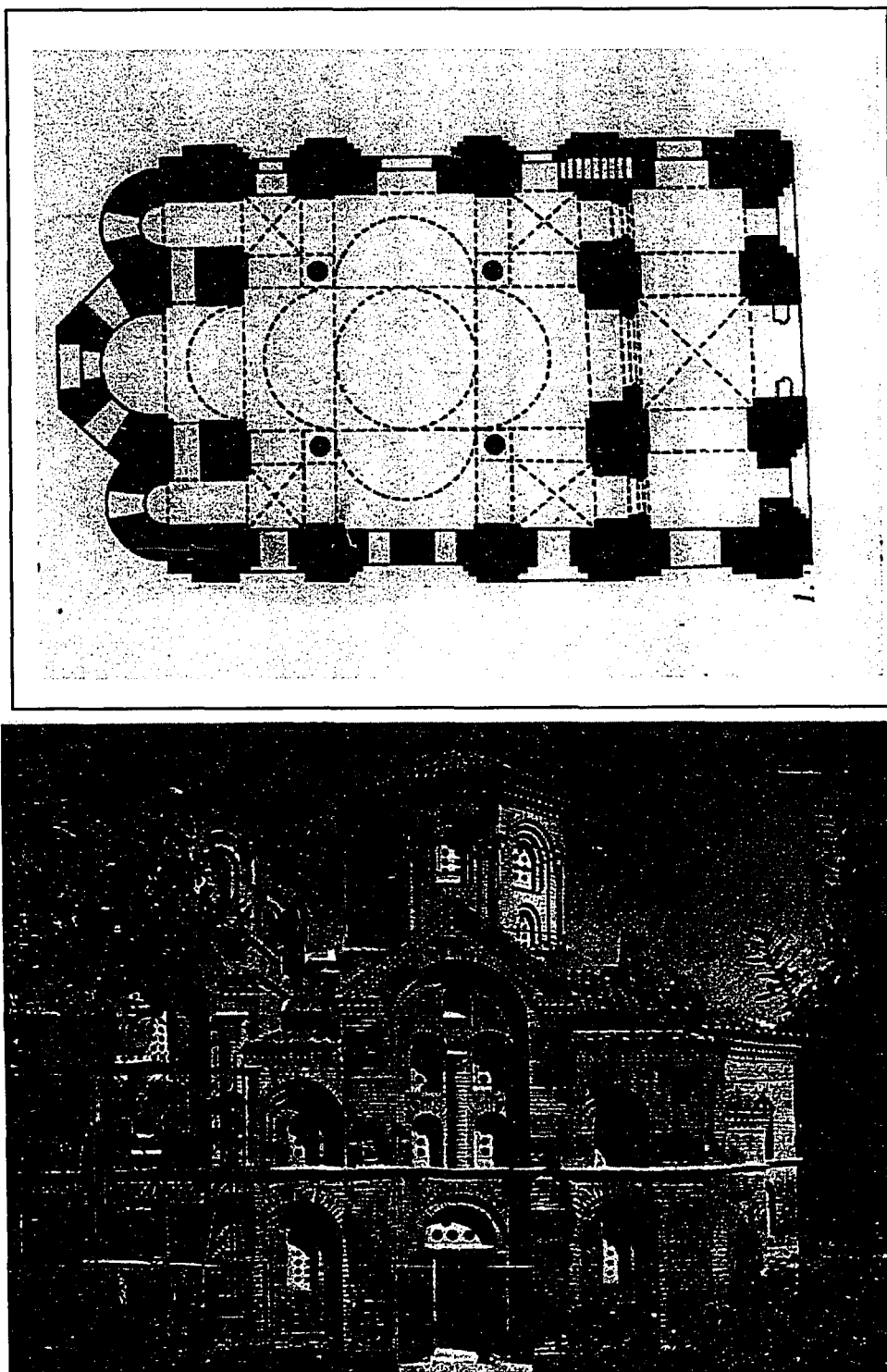


Fig. A1.3 Panagia Chalkeon, Thessaloniki

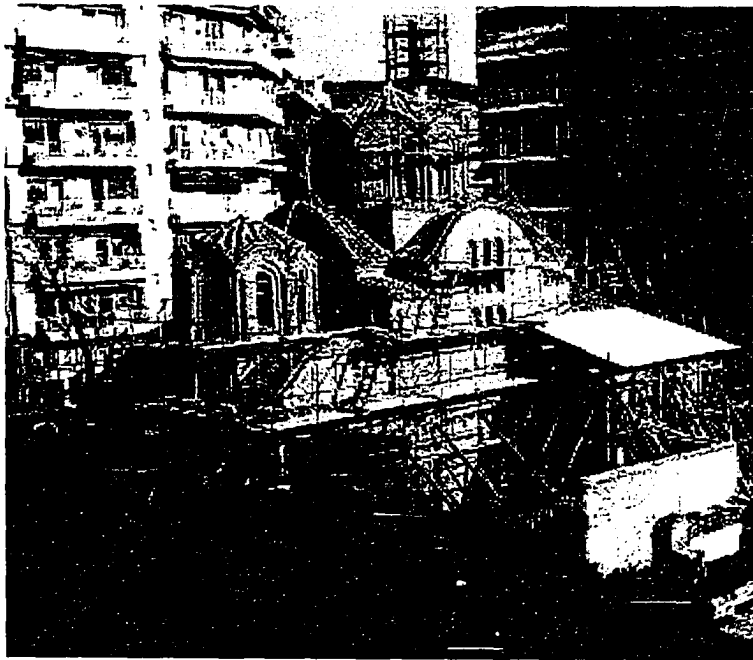
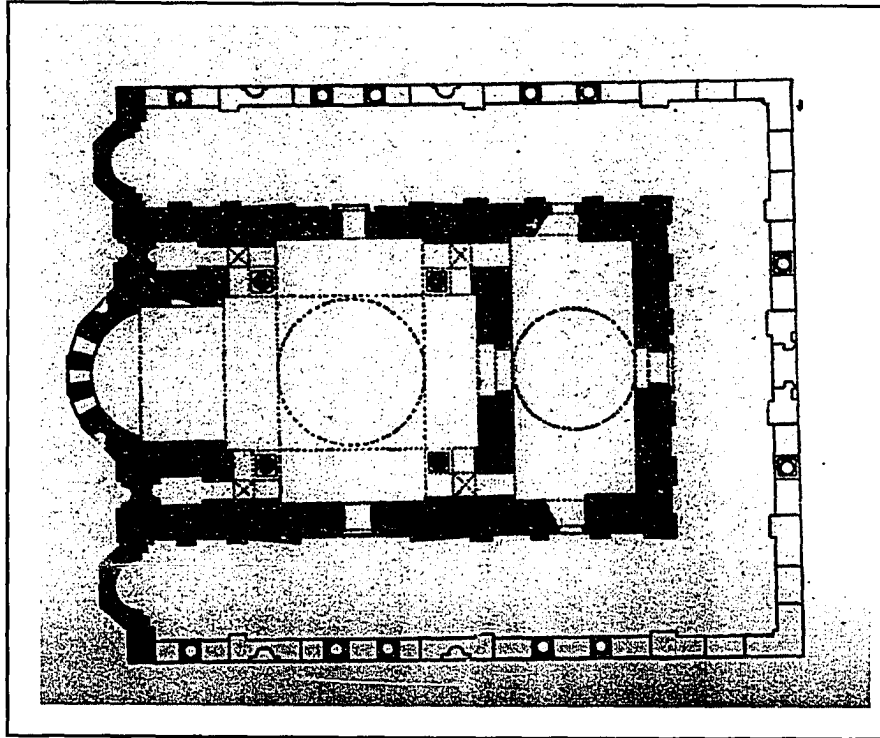


Fig. A.1.4 Panteleemon, Thessaloniki

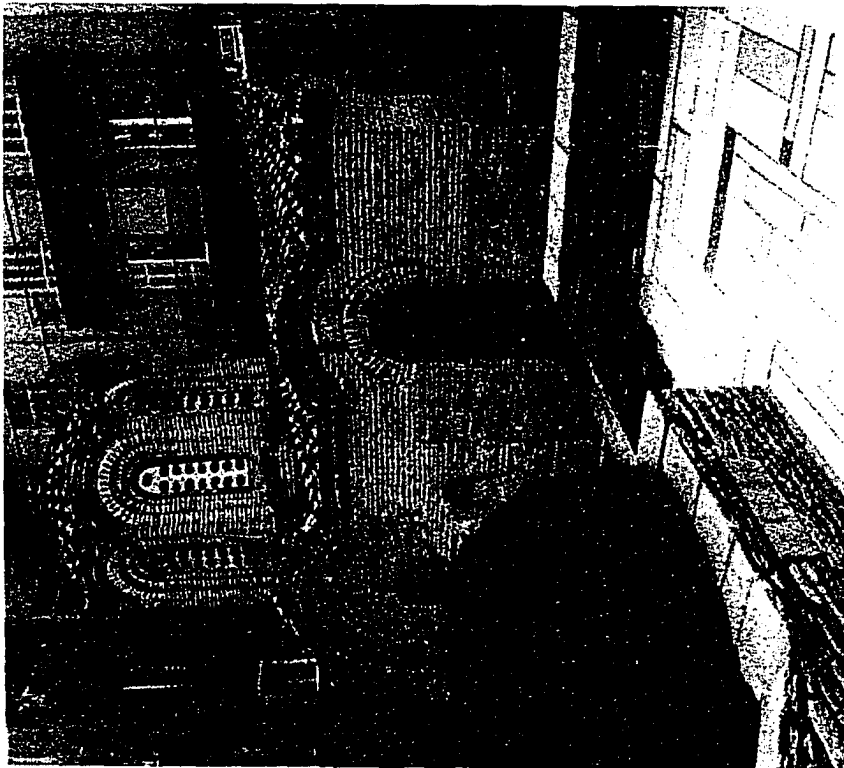
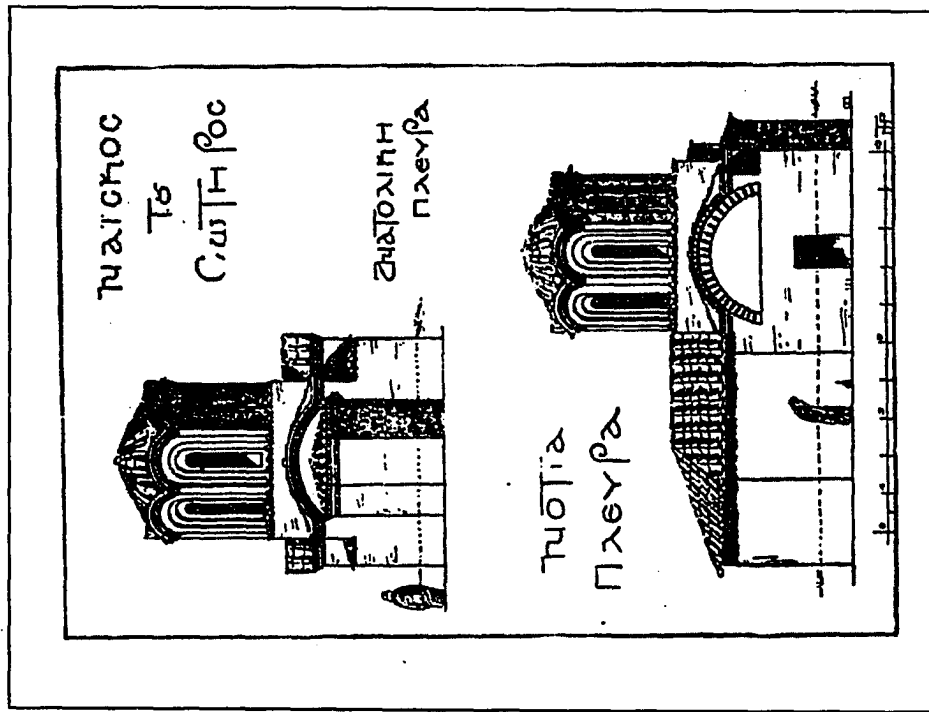


Fig. A.1.5 Metamorphosis, Thessaloniki

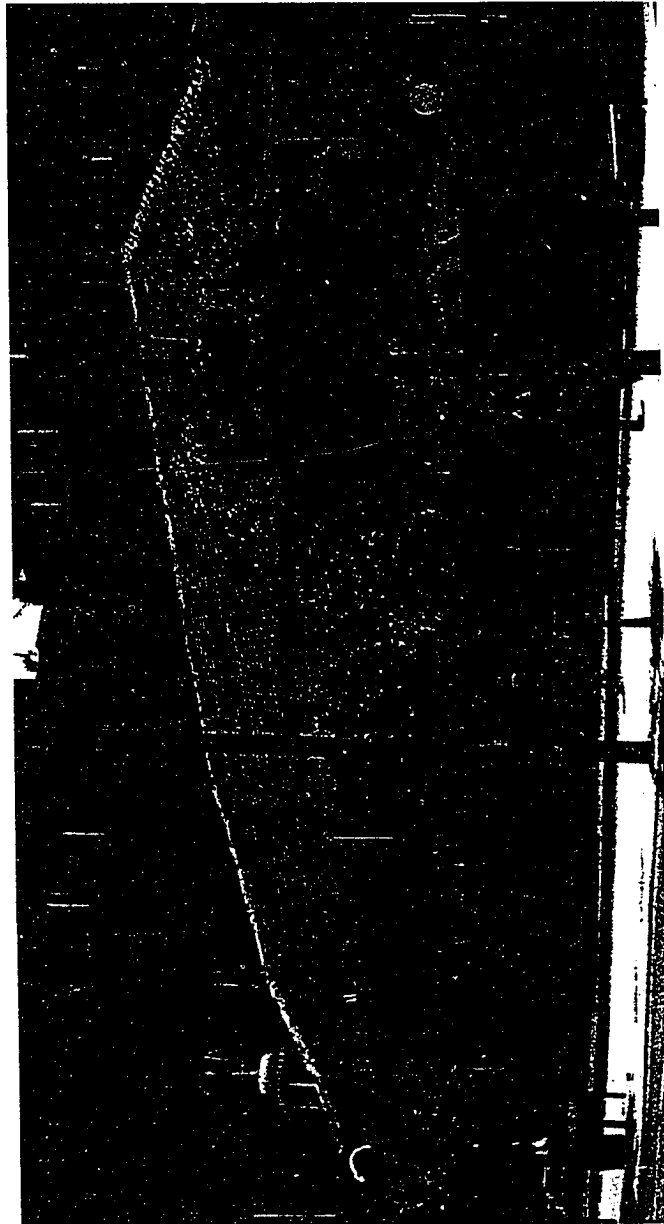


Fig. A.1.6 Ypapante, Thessaloniki

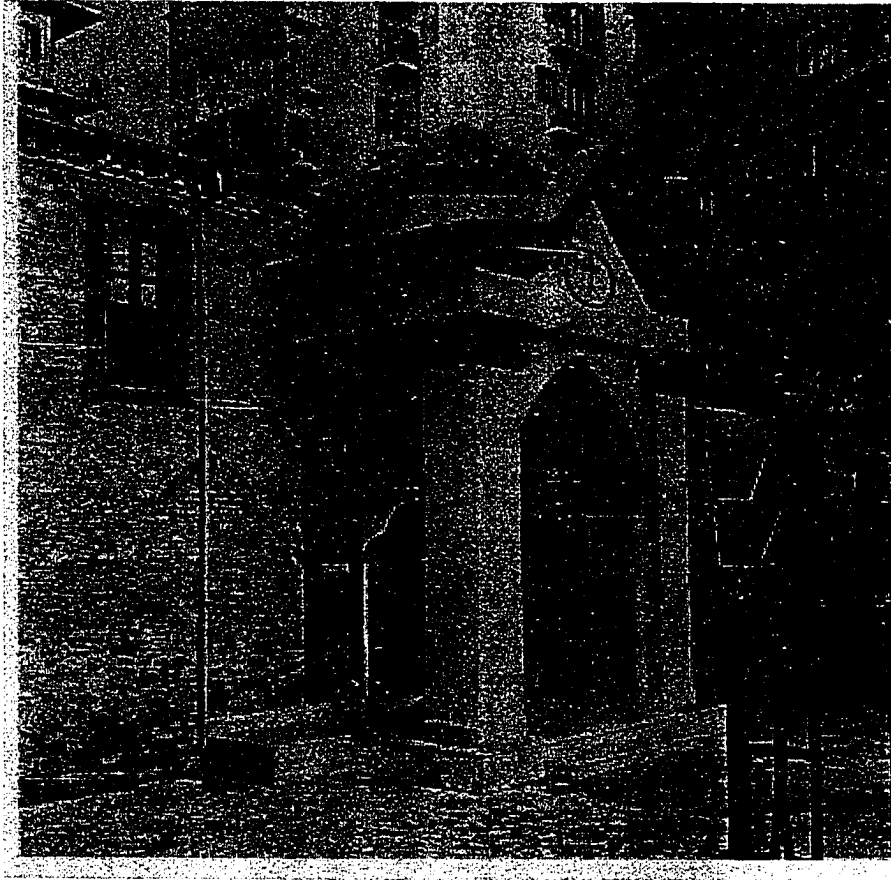


Fig. A.1.7 Nea Panagia, Thessaloniki

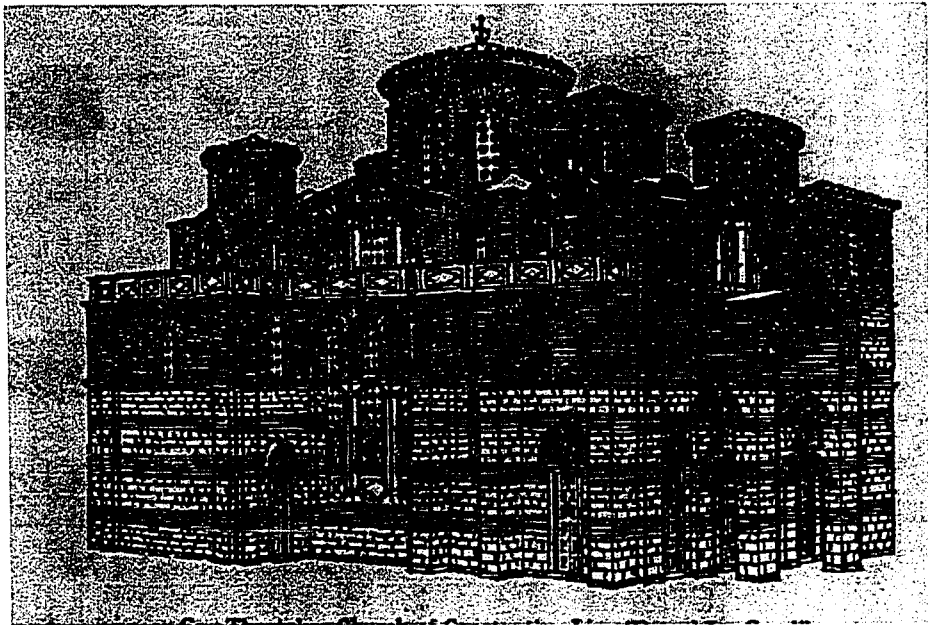
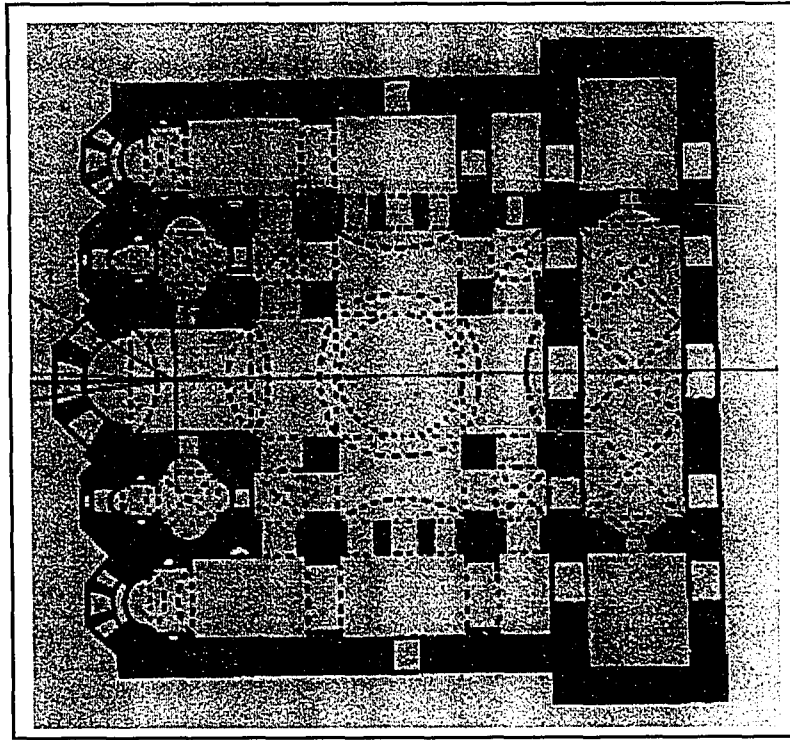
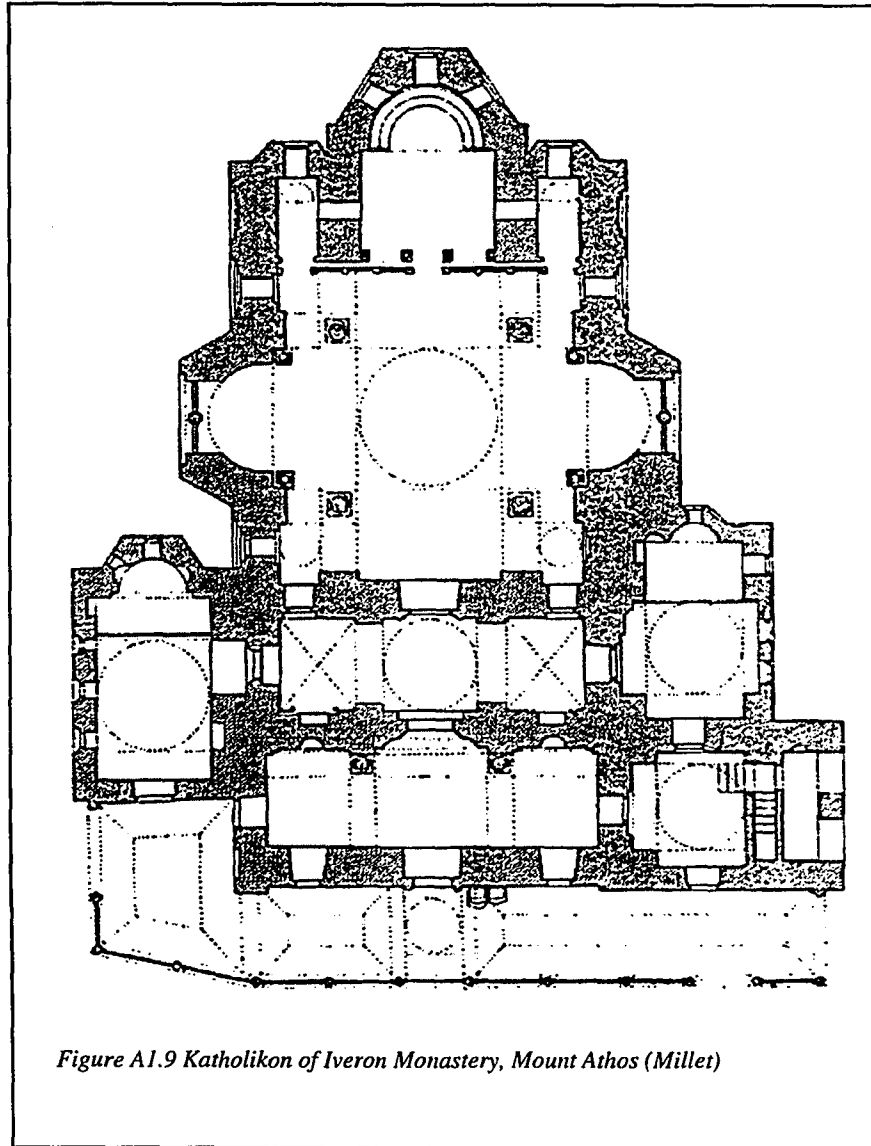


Fig. A.1.8 Lips Monastery, Istanbul



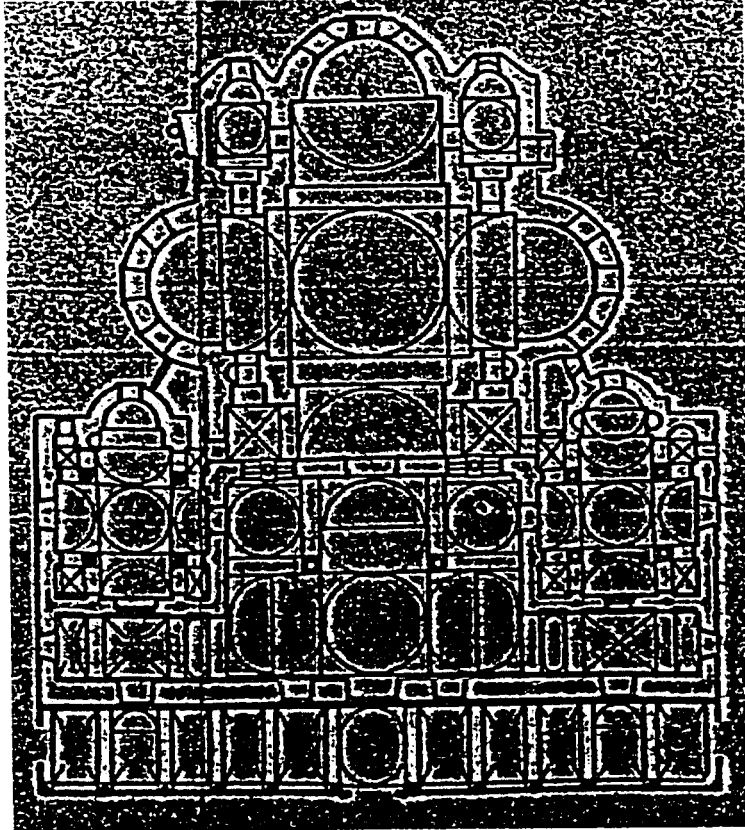
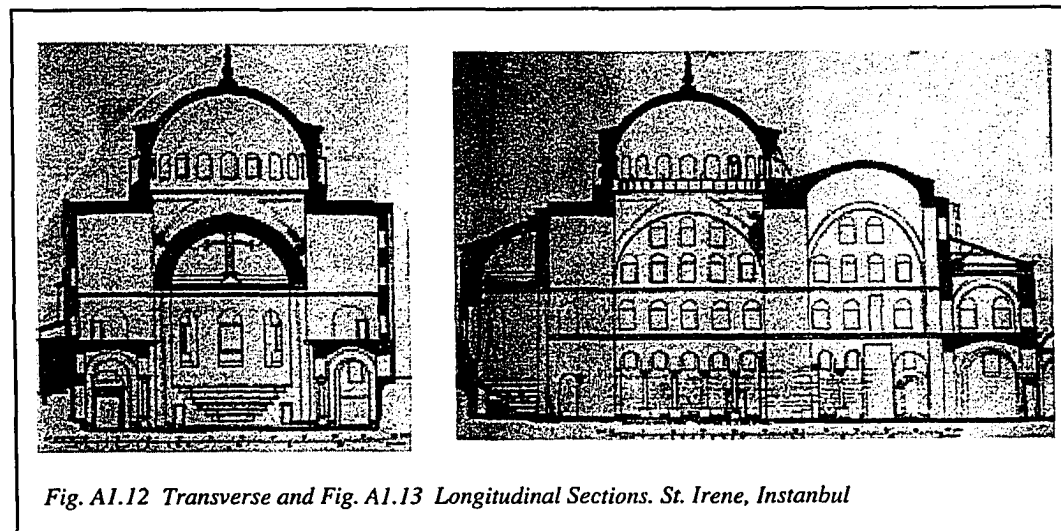
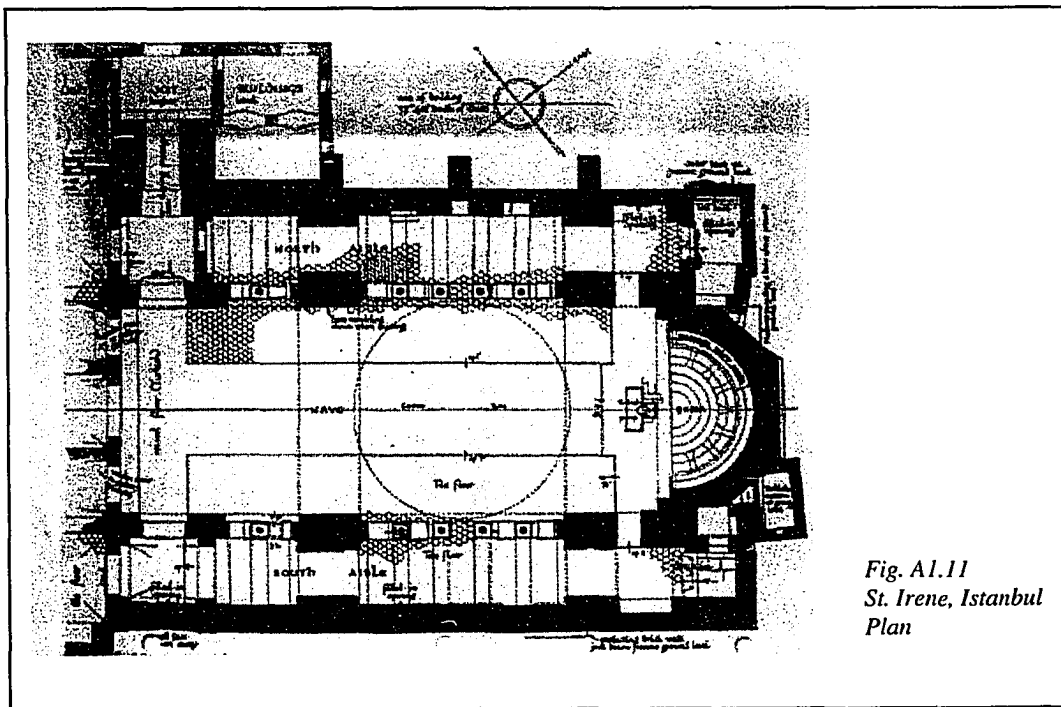
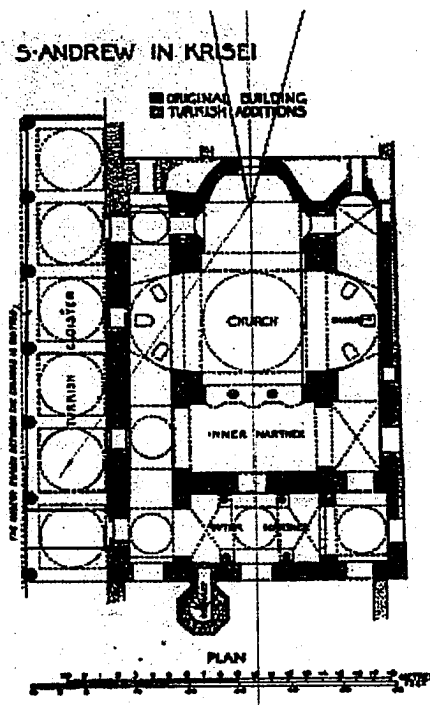


Fig. A1.10 Megisthes Lavras, Mount Athos , Plan (Mylonas)





*Fig. A1.14 Plan St. Andrew en Krisei
Istanbul*

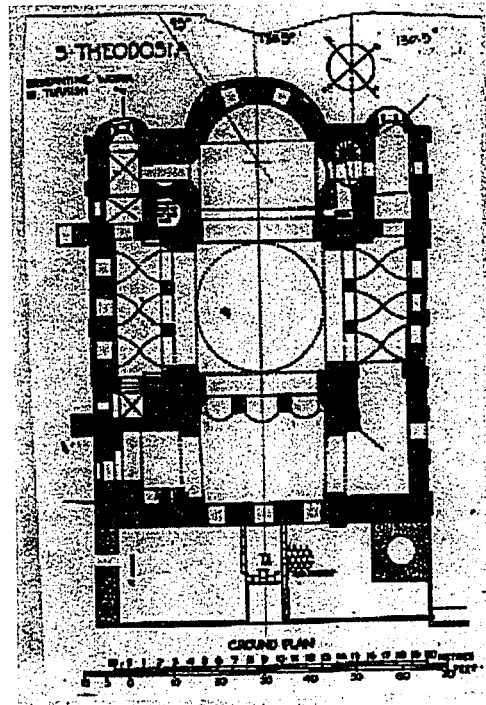
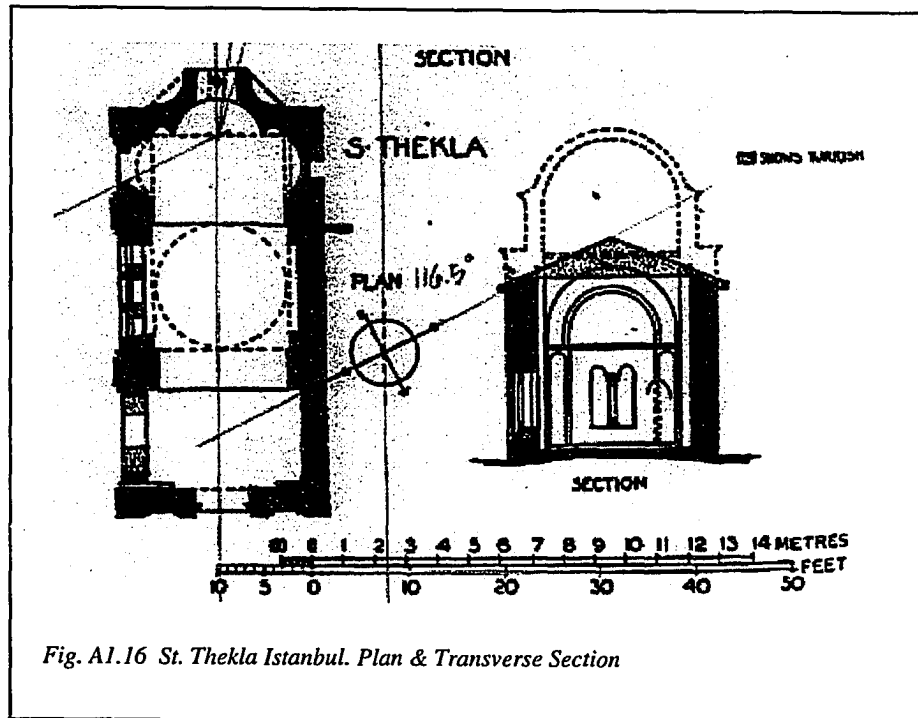


Fig. A1.15 Plan St.Theodosia, Istanbul



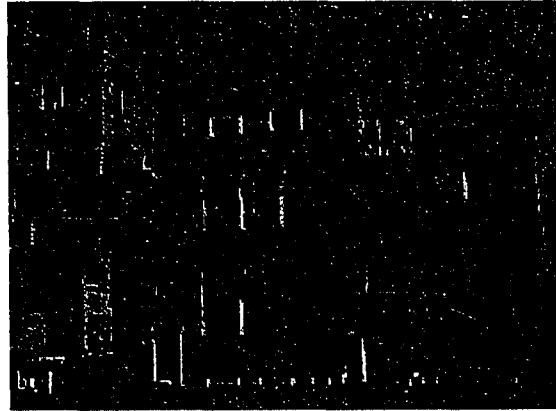


Fig. A1.18 St. Demetrios, Thessaloniki West facade

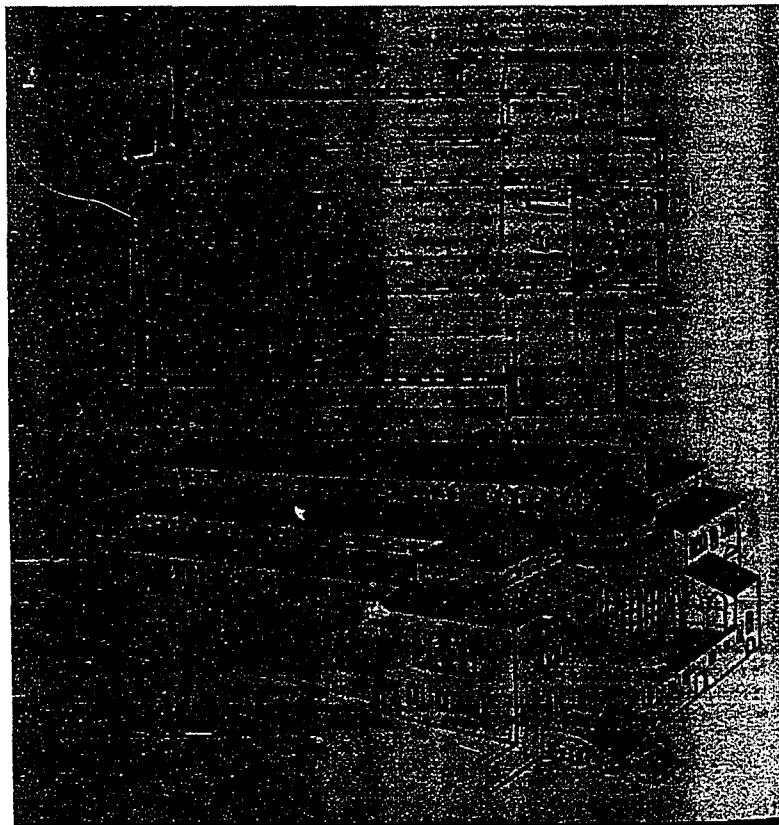
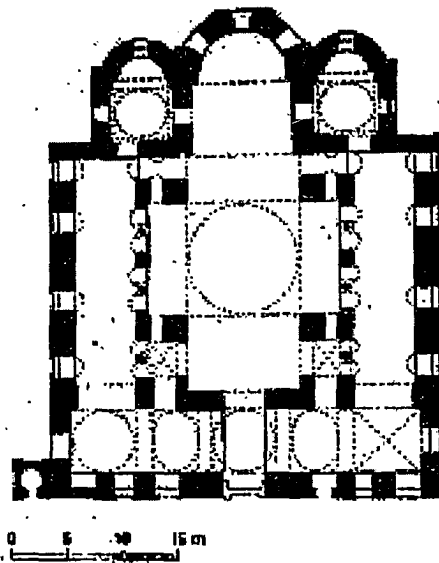


Fig. A1.19 St. Demetrios, Thessaloniki. Perspective&Plan



*Fig. A1.20 Ext. view from East
H. Sophia, Thessaloniki*



*Fig. A1.21 Hagia Sophia,
Thessaloniki, Plan*

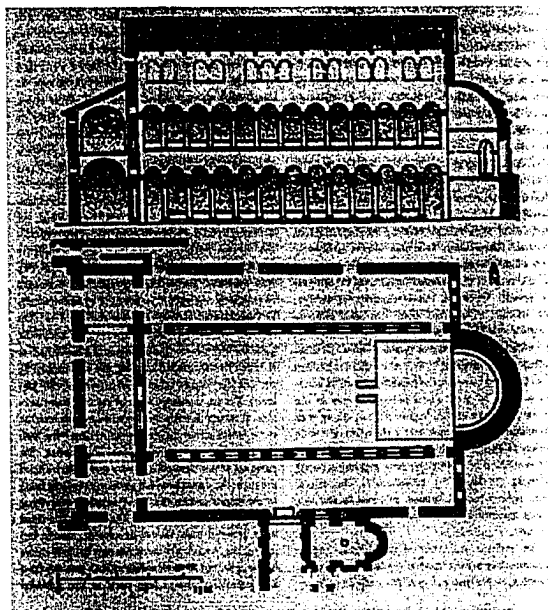
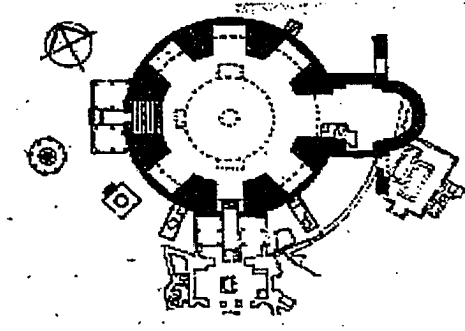


Fig. A1.22 Acheiropoietos, Thessaloniki



*Fig. A1.23 Rotonda, Thessaloniki
Plan*

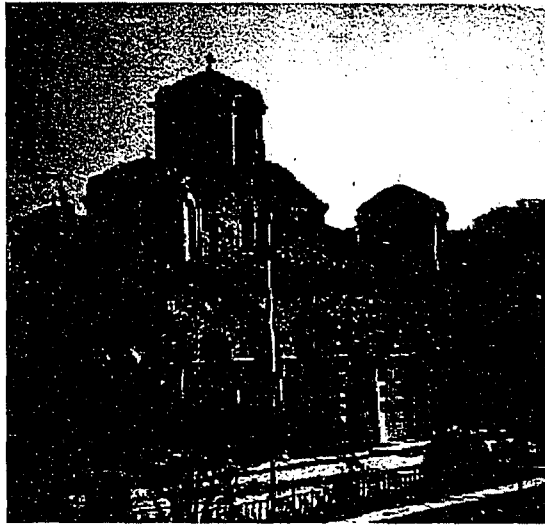


Fig. A1.24 H. Apostoloi, Thessaloniki. W. side

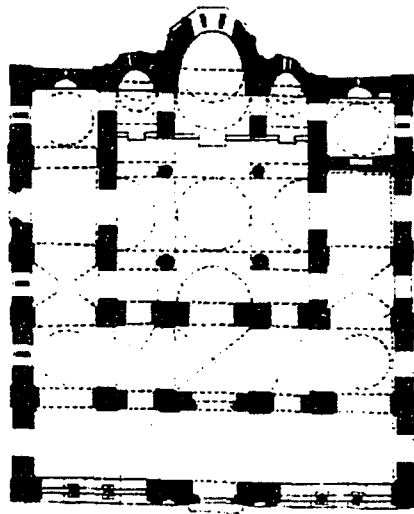


Fig. A1.25 H.Apostoloi, Plan

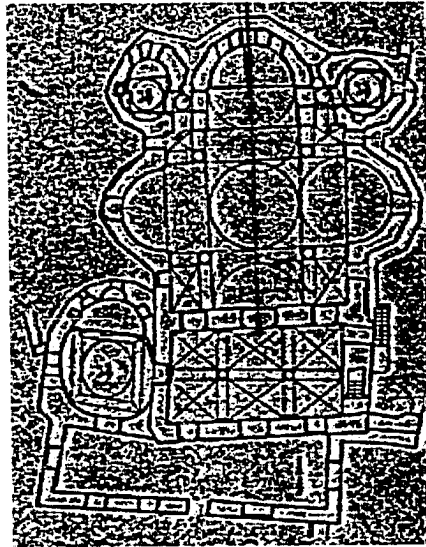


Fig. A1.26 Dionysiou, Plan

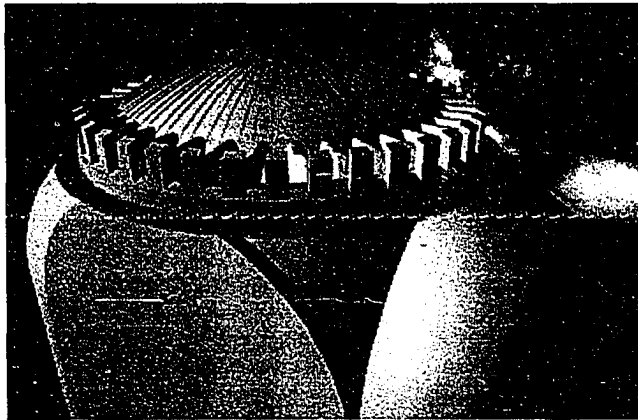


Fig. A1.27 Exterior view of a computer model of original dome H.Sophia, Istanbul.

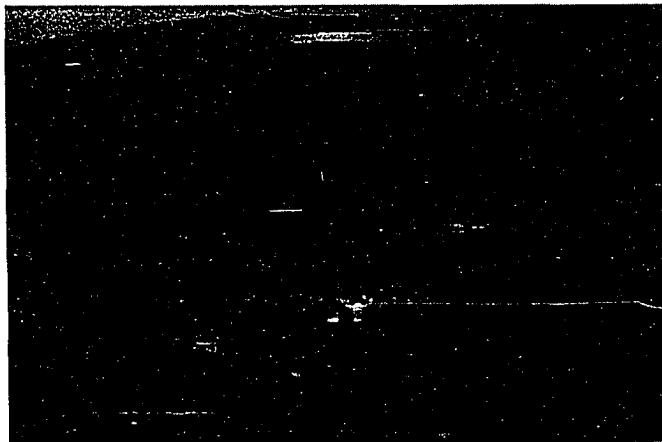


Fig. A1.28 Interior view of computer simulated original dome of H. Sophia, Istanbul

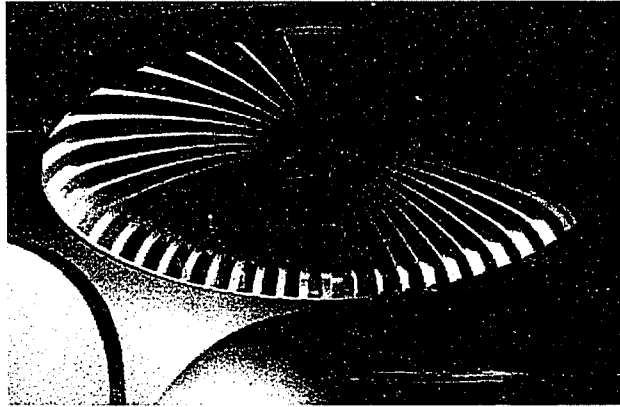


Fig. A1.29 Computer simulation of original dome of H. Sophia, Istanbul with light coming from the South

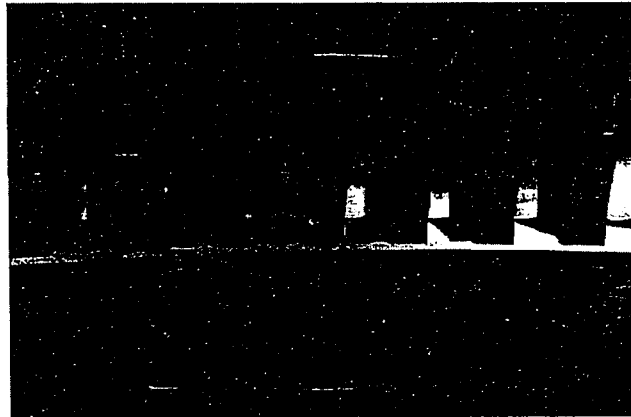


Fig. A1.30 Computer simulation of original dome of H. Sophia, Istanbul. View of Anthemius' elliptical reflectors at window sills.

APPENDIX 2

Table 1
Saint's Name-Day Celebrations (Alphabetical).

Saint's Name	Celebration	Date	
	Byzantine ¹	East (current)	West
Agathonikos	22 August	22 August	
Agion Panton		13 June	
Acacius	8 May	7 May	
Andrew (Apostle)		30 November	
Andrew en Krisei	17 October	-	
Anne & Ioakeim	9 September	9 September	
Anne - conception of Mary	9 December	9 December	
Anne - dormition	25 July	25 July	
Anne the prophet	3 February	3 February	
Anthimos Nikomedeias	3 September	3 September	
Anthony of Constantinople		12 February	
Anthony, Great		17 January	
Apostles - Twelve	30 June	30 June	
Athanasius of Athos	5 July	5 July	
Athanasius		2 May	
Athanasius & Cyril		18 January	
Bartholomew (Apostle)		11 June	
Catherine	25 November	25 November	
Christ - Nativity		25 December	
Christ - Epiphany		6 January	
Christ - Transfiguration	6 August	6 August	
Christ - Candlemas	-	2 February	
Constantinople Founded	11 May		
Constantine and Helen	21 May	21 May	
Cosmas & Damianos	17 October	1 July & 1 Nov.	27 September
David Thessalonikes	-	26 June	
Demetrios Thessalonikes	26 October	26 October	

45 Martyrs Nicopoleos		10 July	
40 Martyrs		9 March	
George	23 April	23 April	
Gregory of Armenia		30 September	
Holy Cross-Apparition	7 May	7 May	
Holy Cross-Exaltation	14 September	14 September	
Holy Cross-Proces./Discov.	1 August	-	
Irene, Great	5 May	5 May	
John Baptist	7 January	7 January	
John Baptist - conception	23 September	23 September	
John Baptist - decapitation	29 August	29 August	
John Baptist-disc. of head	24 Feb&25 May	24 Feb&25 May	
John Baptist - nativity	24 June	24 June	
John Evangelist (Apostle)	26 Sep.& 8 May		27 December
John of Constantinople		2 September	
Laurentius, Osios		10 May	
Laurentius	10 August	10 Aug.& 7 Mar.	
Mark the Evangelist	25 April	25 April	
Martin of Rome	13 April	22 September	12 November
Mary Annunciation	25 March	25 March	
Mary Conception by Anne	9 December	9 December	
Mary Dormition	15 August	15 August	
Mary Entry to the Temple	21 November	21 November	
Mary Girdle of the Virgin	31 August	31 August	
Mary Nativity	8 September	8 September	
Mary Theotokos	26 December	-	
Mary Vestment of Virgin	2 July	2 July	
Matthew Evangelist		16 November	
Menas		11 November	
Menas/Menelaus	10 Dec&11 Nov		
Michael & Gabriel Taxiarches	8 November	8 November	29 September
Michael Archangel	6 September	6 September	
Mocius	11 May	11 May	
Nicephoros Martyr		9 February	

Nicholas		6 December	
Nicholas Thessalonikes		20 June	
Panteleemon	27 July	27 July	
Paul (Apostle)	29 June		
Paul of Constantinople		6 November	
Peter - The Chain of	16 January	16 January	1 August
Peter and Paul (Apostles)	29 June	29 June	
Peter of Athos	12 June	12 June	
Plato of Ankara	18 November	18 November	
Plato the Studite	4 April	-	
Priskos & Nicholas	7 December	-	
Sergius Confessor		13 May	
Sergius & Bacchus	7 October	7 October	
Silvester of Rome	2 January	-	31 December
Simeon Stylites	1 September	1 September	
Simeon Stylites Younger	24 May	24 May	
Sophia, Pistis, Elpis, Agape	17 September	17 September	
Thekla	24 September	24 September	
Theodore		6 March	
Theodore Martyr	2 March	2 March	
Theodosia	29 May	29 May	
Theodota	29 Jul. & 2 Sept.	29 Jul. & 2 Sept.	
Thomas (Apostle)		6 October	
Thyrsus	14 December	14 December	
Tryphon Martyr		1 February	
Zachary-Fath. John Bapt.		5 September	
Zachary from Arta		20 January	
Zachary-Prophet		8 February	

Table 2.
Yearly Calendar of Christian Festivals (by date).

Date	Event	Place of Celebration
January 1	Circumcision & St. Basil the Great	
January 6	Epiphany Blessing of the Waters	
	Palm Sunday	
	Easter Sunday	
	Ascension	
	Pentecost	
March 25	Annunciation	
May 8	St. Acacius	St. Acacius 2
May 11	Foundation of Constantinople /St. Mocius	St. Mocius ³
May 21	St. Const & St. Helena	
June 29	St. Peter and Paul	H. Apostles ⁴
June 30	All the Apostles	H. Apostles ⁵
August 1	Disc. of Holy Cross	
August 6	Transfiguration	
September 2	St. Theodota	St. Theodora ⁶
September 14	Exaltation of the Precious and Life Giving Cross	

November 18	St. Plato	St. Plato ⁷
December 14	St. Thyrsus	St. Thyrsus ⁸
December 25	Nativity - Christmas	

Notes to Appendix 2

¹ From V. Grumel, Traite d'Etudes Byzantines - La Chronologie (Paris: Presses Universitaires de France, 1958):322-7.

² "Two local martyrs had their festivals in this month, St. Acacius on the eighth, and St. Mocius on the eleventh. On these days the special services were held in the churches in honor of these martyrs which had been built by Constantine and rebuilt by Justinian." Downey, Constantinople:116.

³ Ibid.

⁴ "At the end of June, Justinian's new Church of the Holy Apostles was the scene of special festival services on the days devoted to St. Peter and St. Paul (twenty-ninth) and to all the apostles (thirtieth)." Ibid.

⁵ Ibid.

⁶ "Other important festivals in Constantinople were the anniversaries of more local martyrs, such as St. Theodota (September 2), St. Plato (November 18), St. Thyrsus (December 14)." Ibid. It can be assumed that service was held in honor of these Saints in the churches bearing their names.

⁷ Ibid.

⁸ Ibid.

APPENDIX 3

Table 3

List of Churches with Celebration Dates and Orientation Measurements.

1	2	3	4	5	6	7	8	9	10
COUNTRY									
Locale	Latitude/ Longitude	Sr.Az Mm. Az	Eq./Sum./W.Sol ¹ Eq./Sum./W.Sol	Year Mag.Cor ²					
Church Name	Dedication ³	Computer	Calculations	Compass reading ⁴	Apse	Orientation	Constr Date AD	Figure	
	Original Name	Date day/m	Sunrise ⁵ Time-Az	Midmom ⁶ Time - Alt./Az		Measured 7	Published		
GREECE									
Mount Athos	40°-15' N / 24°-15'		90/58/121	1993					
	E		123/92/146	+2.96					
<i>M.Dionysiou</i> ⁸	John Bapt.	24/6				127°	1540	A1.26	
<i>M.Iveron</i> ⁹	Mary-Dormit.	15/8			70°	73°	1030	A1.9	
<i>M.Meg.Lavras</i> ¹⁰	MaryAnnunc.	25/3	5:43-84.6°	8:52-34°/118.2°	94°+	97°	963	A1.10	
	Athan. Athos	5/7	4:33-59.1°	8:16-40°/93.2°					
<i>M.Xeropotamou</i>	Nicephoros	9/2	6:41-106.7°	9:21-25°/136.5°		122° ¹²	956	A1.1	
11	40 Martyrs	9/3	6:01-91.5°	9:01-31.5°/124.2°			1270		
Thessaloniki	40°-43' N / 23°-0'		90/58/	1993					
	E		123/93/147	+2.96°					
<i>Sophia</i>	Sophia	17/9	5:52-87.9°	8:56-32.5°/121.4°	120°+	123°	700	A1.20 A1.21	
<i>Osios David</i> ¹³	Zach.Proph.	8/2	6:48-108.8°	9:24-23.9°/138.2°	110°+	113°	500	A1.2	
	Transfigurat.	6/8	4:59-68.2°	8:29-38.3°/102.9°			820		
<i>Acheiropoietos</i> ¹⁴	Akathistou ¹⁵	varies			120°+	123°	450	A1.22	
<i>Demetrius</i> ¹⁶	Dem.Thess.	26/10			120°+	123°	413	A1.18 A1.19	
<i>Rotonda</i> ¹⁷	George	23/4			120°+	123°	350	A1.23	
<i>P.Chalkeon</i>	Mary-Dormit	15/8			120°+	123°	1028	A1.3	

<i>H.Apostles</i> ¹⁸	Mary-Dorm.	15/8	5:15-73.9°	8:37-37°/108.5°	109°+	112°		1313	A1.24
	H. Apostles	30/6	4:31-58.7°	8:15-39.8°/93.3°					A1.25
<i>Panteleemon</i> ¹⁹	PanteleemonMary	27/7			120°+	123°		1350	A1.4
	Dormit	15/8							
<i>Metamorphosis</i>	Transfigurat	6/8			120°+	123°		1350	A1.5
<i>Ypapante</i>	Candlemas	2/2			120°+	123°		1750	A1.6
<i>Nea Panagia</i>	Mary-Dormit	15/8			120°+	123°		1325	A1.7

TURKEY

Istanbul		41°-2' N / 28°-59'		1993					
E		123.4°/93°/148°		+3.80°					
<i>Sophia</i> ²⁰	Sophia	17/9	5:50-87.2°	8:55-32.6°/121°	120°+	123.8°	123.4°	532	5.40-
	Const-Helen	21/5	4:39-61.4°	8:19-39.4°/96.4°					5.41
	Mary Entry	21/11							
<i>Lips monastery</i> ²¹ (<i>Fenari Isa Camii</i>)	Mary Dormit	15/8	5:09-71.9°	8:35-37.3°/106.8°	110°+	113.8°	114°N,	907	A1.8
	Mary-Nativity	8/9	5:41-83.6°	8:50-33.9°/117.8°			112°S		
<i>Peter & Mark</i> ²² (<i>Attik Paka Camii</i>)	Mark	25/4	5:07-71°	8:33-37.6°/105.9°	128°+	131.8°	126°	550	A1.17
	Ch. of Peter	16/1	7:12-117°	9:36-19.9°/144.2°					
	Peter & Paul	29/6	4:26-57.4°	8:13-39.8°/92.4°					
<i>SergiusBacchu</i> ²³ (<i>KutlukAyaSofii</i>)	SergiusBacchus	7/10	6:17-97.4°	9:08-28.6°/129.6°	100.5°+	104.3°		530	5.32
<i>AndrewKrisei</i> ²⁴ (<i>KocaMusPaka C</i>)	Andrew en Krisei	17/10	6:31-102.5°	9:15-26.4°/133.6°	141°+	144.8°		550	A1.14
<i>Irene</i> ²⁵	Irene	5/5	4:54-66.8°	8:27-38.5°/101.7°	124°+	127.8°	127.7° ²⁶	532	A1.11
									A1.13
<i>Thekla Mar.</i> ²⁷ (<i>Toklu Dede Mesc.</i>)	Thekla	24/9	5:59-90.6°	8:59-31.4°/124°			116.5°	530	A1.16
<i>Theodosia</i> ²⁸ (<i>Gul Camii</i>)	Theodosia	29/5	4:33-59.5°	8:16-39.6°/94.5°	127°+	130.8°	130.5°	550	A1.15

Notes to Appendix 3

¹ For each locale Sun Azimuths are shown for Sunrise (Sr) and Midmorning (Mm) for the days of the Equinox (Eq), Summer Solstice (SS), and Winter Solstice (WS) of 1993. These azimuths are placed directly above the measured orientation of the church axis in order to easily check for alignments with these directions that may be due to various reasons such as for instance astronomical alignments of preexisting pagan temples on which Christian churches may have been built.

² This number is the magnetic correction of the compass reading, and it is time and locale dependent. This one is for readings taken in summer 1993 and it must be added to the readings of this column. The sum is presented as the first number of the next column over to the right where it is compared to the published orientations.

³ Here the day of the celebration of the church is given. It is usually the nameday of the dedicatory Saint or Feast. The original dedicatory day is here of interest since it may have determined church orientation.

⁴ The sun angles calculated with the computer program are compared with the compass readings taken on the site which have been corrected for the year in which they have been taken.

⁵ The first gleam of the sun (rather than full orb is here taken as the point of departure for the calculation of the *third hour*. Also the landscape formation is assumed level. Great mountain ranges in the distance or nearby hills or mountains would have influenced the calculation of the *third hour*.

⁶ Midmorning is calculated as follows: The time that elapses between sunrise and noon is divided in half. This time is entered into the program as the sun-hour angle from the meridian (noon).

⁷ These orientations are those measured by this author and corrected with the appropriate magnetic correction of the compass. These must be compared to the orientations published in various bibliographic sources of column 8 and the numbers in column 5 of the same row or to any of the numbers at the top of column 5 within the box of the locale to which the church belongs.

⁸ The monastery was founded by Osios Dionysios in 1362. It was initially called Nea Petra. The new church substituted older one. P.Chrestou, Odoiporiko sto Agion Oros (Thessal., 1989): 124. The katholikon according to a very precise survey by KEDAK (Kentro Diafylaxes Agioreitikes Kleronomias) was measured to be oriented at 127° from N. The sun aligns with the altar on the equinox midmorning. The line of alignment touches the northernmost reveal of the central apse window.

⁹ The monastery was founded by kouropalates Ioannes Iver or by the general Ioannes Tornikios in 980. It had been primarily Georgian. P.Chrestou, Odoiporiko sto Agion Oros (Thessal., 1989): The timekeeping in this monastery is different than in the rest of M. Athos.

¹⁰ P.K. Chrestou, Odoiporiko sto Agion Oros (Thessal., 1989):99 and Nikodemou Lavriotou Megiste Lavra Eikonographemenos Odegos Proskynetarion (Ag. Oros, 1988). Also see G. Millet, L'Ecole Grecque dans l'Architecture Byzantine (Paris: E. Leroux, 1916). Monastery founded by St. Athanasius Athonite. Functions according to Typikon (970) based on the Typiko of Studius, based in turn on the canon of Basil the Great. Typiko Tsimiske (972). Millet, Monuments de l' Athos also see Actes de Lavra.

¹¹ The monastery was founded by the monk Pavlos Xeropotamenos before 956. Until 1270 it was referred to as dedicated to Ag. Nicephoros. From 1270 is referred to as dedicated to the 40 martyrs. P.Chrestou, Odoiporiko sto Agion Oros (Thessal., 1989):142-3.

¹² A precise survey of the monastery by KEDAK shows the katholikon axis at an angle of 122° from N. The 40 Martyrs feast is accommodated through the central apse window and very close to the center. The same is true for the angle of the equinox. In the day of St. Nicephorus the sun comes in through the southern apse window aligned with its left reveal.

¹³ Built by Theodora, daughter of the emperor Maximilianos Galerios. Since the early 9th century the monastery was called Christ Savior. It became Osios David since 1921. Precursor of the cross-domed type. A. Papagiannopoulos:57-8. See Also E.N. Tsigaridas, Oi Toihographies tes Mones Latomou Thessalonikes kai he Vyzantine Zografike tou 12ou aiona (Thessalonike: Etaireia Makedonikon Spoudon, 1986):9, 14. Also see A. Xyngopoulos, "To Katholikon tes Mones Latomou en Thessalonike kai to en auto psefidoton," Arhaiologikon Deltion 12 (1929):142-80. There is a bilobe window in the apse. It accommodates both the celebration dates of Zachary the prophet and Christ's Transfiguration.

¹⁴ Perimetrical light. Particularly bright church. Naos Parthenou Theotokou Acheiropoiitou Odegetrias. A. Papagiannopoulos:52-4.

¹⁵ 5th week of Cheretismon.

¹⁶ Founded by the emperor Leontios. See A. Papagiannopoulos, Mnemeia tes Thessalonikes (Thessaloniki: Rekos,n.d.):45.

¹⁷ Built by Galerios and has also been named as Naos ton Asomaton and as Ag. Georgios. A. Papagiannopoulos:34-36.

¹⁸ Originally a monastery dedicated to the Virgin founded by patriarch Niphon. Cross in square (on 4 columns) with U shaped gallery with domes at the four corners. The east bay of the north gallery was used as a chapel dedicated to St. John the Baptist. See Mango, Byzantine Architecture :277 and S. Curcic, "The Twin-domed Narthex in Paleologan Architecture," ZVI, 13(1791):333ff. Also, Diehl, Le Tourneau, and Saladin, (1918), also Texier and Pullan, Byzantine Architecture (London, 1864): 148. This church was devoted to the Virgin. On Mary's Dormition celebration date in 1312 the sun azimuth is 108.5° in midmorning. The sun aligns with the altar through the central part of the trilobe apse window. The sun also aligns with the altar through the northernmost lobe of the window touching the window reveal.

¹⁹ Papagiannopoulos: 83-4.

²⁰ Built by Constantine and rebuilt by Constantius Theodosios II and finally by Justinian. Downey refers to 34 churches that have been built by Justinian. Downey, Constantinople in the Age of Justinian: 100. The architects were Anthemius of Tralles and Isidorus of Miletus the Elder. See also Van Millingen:85; also Mainstone, Hagia Sophia:129. Until Paleologan times when the *ikonostasis* was introduced, a marble screen, that afforded a view of the apse, was used. See Mango, Byzantine Architecture: 295.

²¹ Built by the emperor Constantine Lips. Mango: 199, 204. See for orientation Van Millingen Fig.5. Also consult T. Macridy, A.H.S. Megaw, C. Mango, E.J. Hawkins, "The Monastery of Lips at Istanbul," DOP 18 and C. Mango, J.W. Hawkins, "Report on Field Work in Istanbul and Cyprus, 1962-3."

²² In this case it appears that there is a 6° difference between Van Millingen's orientation of the church and my measurement. It appears that the sun was aligned with Mark's celebration, on April 26th, through the left northernmost window and with Peter's on January 16th, through the right, southernmost window.

²³ Built by Justin and Justinian. Procopius: 18-20. This church is called little Agia Sofia because it shares the style of Hagia Sophia and it is thought as having furnished the model of St. Vitale at Ravenna (see also Van Millingen:70). It is also attributed to Anthemius of Tralles (note p.18). ". . . each alike reflects the rays of the sun from its polished marble, and is alike covered with lavish gilding and adorned with offerings. . . ." (p.19-20). Also see A.E. Henderson, Builder (Jan. 1906). Similarity also with cathedral of Bosra (511-12) Van Millingen:70 n.2 and Fergusson, History of Ancient and Medieval Architecture vol.I:432. Swift maintains that SS. Sergius and Bacchus is an authentic early work of Anthemius. Swift, Hagia Sophia: 37. It is near Hormisdas palace. The dome is carried on an octagon without pendentives and it has sixteen alternating round and flat compartments A. Van Millingen: 76-9 and Figs.28, 29; also see Henderson, Builder (Jan. 1906). Mango, Byzantine Architecture: 101-7. Drawings (figs.109-10 in Mango) after P. Sanpaulesi, "La Chiesa dei SS. Sergio e Bacco a Constantinopoli," Rivista dell' Istituto Nazionale di Archeologia e Storia dell' Arte, n.s. 10 (1961):116ff; also A. van Millingen, Byzantine Churches in Constantinople:62-83, also Mathews, The Early Churches of Constantinople:42ff; also Ebersolt and Thiers, Eglises:21ff; also Mango, "The Church of Sts. Sergius and Bacchus at Constantinople. . ." Jahrbuch der Österreichischen Byzantinistik, 21 (1972):189ff. As measured the axis of the church aligns with 104.3° azimuth. If this is a church designed by Anthemius and the altar is placed approximately in the same position as in Hagia Sophia then it aligns with the mid-morning azimuth of the sun of 129.6° in the Saint's nameday, through the lower right, southernmost window for at least 15 minutes.

²⁴ Built by Theodora. Van Millingen:106-121. The church lies to the east of the Gate of Selivria. p.106 It holds the remains of the iconodule St. Andrew of Crete.p.113. Also see Diehl, Manuel d' Art Byzantin: 74 Fig.26. See also Van Millingen:117. The church stood on the Seventh Hill of the city already in the 6th C. Van Millingen:108, 110-11. The church has a single window in the apse. The leftmost reveal of the apse window allows the sun to align with the altar just when 133.6° azimuth, that is midmorning of the Saint's nameday.

²⁵ Initially built by Constantine was later rebuilt by Justinian and remodeled by Leo the Isaurian or Constantine the Copronymus. George, The Church of St. Eirene at Constantinople also Mango, Byzantine Architecture: 154, figs.164-5. It was called the

Ancient or the Old Church and it was the cathedral of the city before the first Hagia Sophia was built. Van Millingen: 84-5. According to Van Millingen: Fig. 31 see also pages 84-105. With elliptical dome or according to Van Millingen "domical vault." Van Millingen: 94. "The drum of the dome is pierced by twenty semicircular-headed windows (of which only five are now open), and as their arches and the dome spring at about the same level the heads of the windows impinge upon the dome's surface." Van Millingen: 99. The upper part of the building, the apse, the dome-arches, the dome-vault, and the dome with its drum, belong to the reconstruction of the church after that earthquake of 740. Van Millingen: 102.

²⁶ George, The Church of St. Eirene plate 1 and p. 9

²⁷ Built by Justin and Justinian. Procopius:23. The axis of this church is oriented at an azimuth of 116.5°. There is a 2 lobe window in the apse and the single column is aligned with the axis. In mid-morning of St. Thekla nameday the sun enters at 124° azimuth and aligns with the altar, through the right, southernmost window until it disappears at 132° azimuth, half-hour later. The church of St. Thekla was restored by Justinian. St. Thekla suffered in the first century AD. Downey, Constantinople:94.

²⁸ In this church there is no central window in the apse. There are only two windows one on each side. The left northernmost window aligns with a 94.5° sun azimuth.

APPENDIX 4

About Paradoxical Machines¹

It is required to cause a ray of the sun to fall in a given position, without moving away, at any hour or season. Let the given position be at A, and through A let a meridian line AB be drawn parallel to the horizon, as far as the slit or door through which the rays are required to penetrate to A. Let BG be drawn through B normal to AB, so that it is equinoctial. And let there be another straight line BD, for the summer solstice, and similarly let BE be a winter ray. Let there be taken at an appropriate distance from B, according to the size of the reflector we desire to construct, on the winter ray first, a point Z on BE. Join ZA. Next let the line ZH bisect the angle EZA, the point H being conceived between the winter ray and the equinoctial ray, as lying on the line bisecting the angle EZA which is produced to Q. If we suppose a plane mirror to lie along the straight line HZ, I say that the ray BZE striking HZQ will be reflected to the point A. For since the angle HZA equals the angle EZH, and the angle EZH is equal to the vertical angle QZB, it is obvious that the angle HZA is equal to the angle QZB. Then at equal angles the ray BZ will be reflected to A along ZA. Similarly we shall cause the equinoctial ray to be reflected as follows: let the straight line HA be joined, and with centre H and radius HA let an arc be drawn cutting BG in K, so that HA is equal to HK. And likewise let the straight line HLM bisect the line KHA, intersecting the straight line BGK at L, and terminating at M at the straight line which bisects the angle GBD. Join LA. Therefore, since HK is equal to HA, and the angle KHA is bisected by the straight line HLM, the base KL is equal to LA and consequently the angle KLM is equal to the angle MLA. But the angle KLM is equal to the angle HLB; for they are vertical angles: then the angle MLA is equal to the angle HLB. Hence, if HLM is similarly considered to be a plane mirror with a continuous surface and joined to the mirror HZQ already

described, the equinoctial ray LB will be reflected in the direction of A along the straight line LA. Similarly, by the same construction on the straight line DB, we shall show that the summer ray BX which falls on the plane mirror on MXO will be reflected to A along the straight line XA. If then we suppose a hole placed symmetrically about the point B as centre, all the rays falling through the hole, that is through the point B, upon the continuous mirrors already described will be reflected to A. And by repeated bisection of the said angles and by the construction of more and more smaller mirrors it is possible to describe QZHLMXO, which if considered to be around BA as axis will form the so-called oven shaped mirror, which being bisected and covered with a lid parallel to the horizon, and receiving the rays only through B, will send them, whatever their angle of incidence, to the point A. But to avoid the effort of continuous division in constructing and putting together plane mirrors, we shall demonstrate how, after the line (scil. AB) has been drawn, a surface of incidence may be drawn to it so as to make a curved reflector with the required properties. (The text and meaning are uncertain here). For if we consider the line PZ to be equal to the straight line ZA, the straight line PH is equal to HA. Then since the straight line PZ was made equal to ZA, let ZB be on the same line; then the whole of PB is equal to BZ, ZA. But PB is equal to KB, because PH is equal to HK and the angle PBK is bisected by BH. Then BK is equal to BZ, ZA. But BK is equal to BL, LA, because KL is equal to LA and LB is common. Then the two lines BL, LA are equal to the two BZ, ZA. By the same reasoning it may be shown that BN is equal to BK and to PB: and BX, XA are equal to BL, LA and BZ, ZA to both. Accordingly it may be shown that the rays which pass through B and are reflected to A are all equal to the others having the same property. If, then, we stretch a string surrounding the points A, B tightly around the first point from which the rays are to be reflected, the line will be drawn which is part of the so-called ellipse, with respect to which the surface of the mirror must be situated.

Notes to Appendix 4

¹ Anthemius in G.L.Huxley, Anthemius of Tralles: A Study in Later Greek Geometry (Cambridge, MA.: Eaton Press, 1959):6-9.

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